FREE SUPPLEMENT

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

Vol.32 No.5

EVERYDAY PRACTICAL ELECTRONICS

CAN $6.99/US $4.95

FREE SUPPLEMENT

PIC TUTORIAL V2
Part 2 - The best introduction to using PIC microcontrollers

SUPER MOTION SENSOR
Highly sensitive auto-adjusting design

DOOR CHIME
Electronic Ding Dong

PLUS

BACK TO BASICS 4
LIVE WIRE DETECTOR • MW RADIO
Two easy to build projects

Printed in the UK

http://www.epemag.wimborne.co.uk

Colour CCTV camera, 8mm lens, 12V d.c. 200mA 582x628 Resolution 380 lines Automatic aperture lens Mirror function PAL Back Light Compensation MLR, 100x40x40mm. Ref EE2 £69

Built-in Audio .15lux CCD camera 12V d.c. 200mA 480 lines s/n ratio >48db 1v P-P output 110x60x50mm. Ref EE1 £99

Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in. Available in two sizes 1 – 100x10x170mm and 2 – 100x70x280mm. Ref EE6 £22 EE7 £26 multi-position brackets. Ref EE8 £8

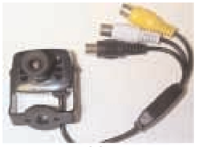
Excellent quality multi-purposeTV/TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV. Ideal for use in boats and caravans 49.7MHz-91.75MHz VHF channels 1-5,168.25MHz-222.75MHz VHF channels 6-12, 471.25MHz-869.75MHz, Cable channels 112.325MHz-166.75MHz Z1-Z7, Cable channels 224.25MHz-446.75MHz Z8-Z35 5" colour screen. Audio output 150mW. Connections, external aerial, earphone jack, audio/video input, 12V d.c. or mains, Accessories supplied Power supply, Remote control, Cigar lead power supply, Headphone Stand/bracket. 5" model £139 Ref EE9, 6" model £149. Ref EE10

Fully cased IR light source suitable for CCTV applications. The unit measures 10x10x150mm, is mains operated and contains 54 infra-red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra red lamp when the light level drops below a preset level. The infrared lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras. £49. Ref EE11

This device is mains operated and designed to be used with a standard CCTV camera causing it to scan. The black clips can be moved to adjust the span angle, the motor reversing when it detects a clip. With the clips removed the scanner will rotate constantly at approx 2.3rpm. 75x75x80mm £23. Ref EE12

Colour CCTV Camera measures 60x45mm and has a built in light level detector and 12 IR LEDs .2 lux 12 IR LEDs 12V d.c. Bracket Easy connect leads £69. Ref EE15

A high quality external colour CCTV camera with built in Infra-red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4' CCD 542x588 pixels 420 lines .05 lux 3.6mm F2 78 deg lens 12V d.c. 400mA Built in light level sensor. £99. Ref EE13



A small compact colour CCTV camera measuring just 35x28x30mm (camera body) Camera is supplied complete with mounting bracket, built in IR, microphone and easy connect leads. Built in audio Built in IR LEDs Colour 380 line resolution PAL 0.2 us +18db sensitivity. Effective pixels 628x582 Power source 6-12V d.c. Power consumption 200mW £36. Ref EE16

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4GHz 3 lux 6-12V d.c. manual tuning Available in two versions, pinhole and standard. £79 (pinhole) Ref EE17, £79 (standard). Ref EE18

Small transmitter designed to transmit audio and video signals on 2.4GHz. Unit measures 45x35x10mm.Ideal for assembly into covert CCTV systems Easy connect leads Audio and video input 12V d.c. Complete with aerial Selectable channel switch £30. Ref EE19

2.4GHz wireless receiver Fully cased audio and video 2.4GHz wireless receiver 190x140x30mm, metal case, 4 channel, 12V d.c. Adjustable time delay, 4s, 8s, 12s, 16s. £45. Ref EE20

Colour pinhole cctv camera module with audio Compact colour pinhole camera measuring just 20x20x20mm, built-in audio and easy connect leads PAL CMOS sensor 6-9V d.c. Effective Pixels 628x582 Illumination 2 lux Definition >240 Signal/noise ratio >40db Power consumption 200mW £35. Ref £35

Self-cocking pistol plcr002 crossbow with metal body. Self-cocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy. Adjustable rearsight 50lb drawweight 150ft sec velocity Break action 17" string 30m range £21.65 Ref PLCR002 **INFRA-RED FILM** 6" square piece of flexible infra-red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra-red output only using standard light bulbs Easily cut to shape. 6" square £15. Ref IRF2 or a 12" sq for £29 IRF2A **NEW 12V 12" SQUARE SOLAR PANEL** Kevlar backed, 3watt output. Copper strips for easy solder connections £14.99. Ref 15P42 **PACK OF 4 JUST £39.95. REF 15P42SP**

Dummy CCTV cameras These motorised cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with rawl plugs and fixing screws. Camera also has a flashing red LED built in. £9.95. Ref CAMERAB

BULL ELECTRICAL

UNIT D, HENFIELD BUSINESS PARK,
HENFIELD, SUSSEX BN5 9SL
TERMS: CASH, PO OR CHEQUE WITH ORDER
PLUS £5.50 P&P (UK) PLUS VAT.
24 HOUR SERVICE £7.50 (UK) PLUS VAT.
OVERSEAS ORDERS AT COST PLUS £3.50

(ACCESS/VISA/SWITCH ACCEPTED)

'phone: 01273 491490 Fax 491813

Sales@bullnet.co.uk

POWERSAFE DEEP CYCLE BATTERIES

6V 100AH NOW ONLY £19 EACH

12V 51AH NOW ONLY £29.95 EACH

We also have some used 2.3AH 12V (same as above) these are tested and in good condition and available at an extremely good price for bulk buyers, box of 30 just £49.99. Ref SLB23C

Aiptek Pocket DV Up to 2000 still pics before requiring download!! The all new Pocket DV, it's amazing . . . such advanced technology, such a tiny size – you will be the envy of your friends!! This camera will take up to 3.5 minutes of Video and Audio, up to 2000 digital still pictures or 30 minutes of voice recording! Then just connect it to your PC via the USB cable (Supplied) and after transferring the data you can start all over again!! £69. Ref POCKETDV

The smallest PMR446 radios currently available (54x87x37mm).These tiny handheld PMR radios not only look great, but they are user friendly & packed with features including VOX, Scan & Dual Watch. Priced at £59.99 PER PAIR they are excellent value for money. Our new favourite PMR radios! Standby: – 35 hours Includes: – 2 x Radios, 2 x Belt Clips & 2 x Carry Strap £59.95 Ref ALAN1 Or supplied with 2 sets of rechargeable batteries and two mains chargers £84.99. Ref Alan2

Beltronics BEL55O Euroradarand GATSO detector Claimed Detection Range: GATSO up 400m. Radar & Laser guns up to 3 miles. Detects GATSO speed cameras at least 200 metres away, plenty of time to adjust your speed £319. Ref BEL550

Fully Portable – Use anywhere Six automatic programmer for full body pain relief, shoulder pain, back/neck pain, aching joints, rheumatic pain, sports injuries EFFECTIVE DRUG FREE PAIN RELIEF TENS (Transcutaneous Electrical Nerve Stimulation) units are widely used in hospitals, clinics throughout the United Kingdom for effective drug free pain relief. This compact unit is now approved for home use. TENS works by stimulating nerves close to the skin releasing endorphins (natures anesthetics) and helping to block the pain signals sent to the brain. Relief can begin within minutes, and a 30 minute treatment can give up 12 hours relief or more. TheTENS mini Microprocessors offer six types of automatic programme for shoulder pain, back/neck pain, aching joints, Rheumatic pain, migraines headaches, sports injuries, period pain. In fact all over body treatment. Will not interfere with existing medication. Not suitable for anyone with a heart pacemaker. Batteries supplied. £19.95 Ref TEN327 Spare pack of electrodes £5.99. Ref TEN327X

SHOP ONLINE
AT
WWW.BULLNET.CO.UK

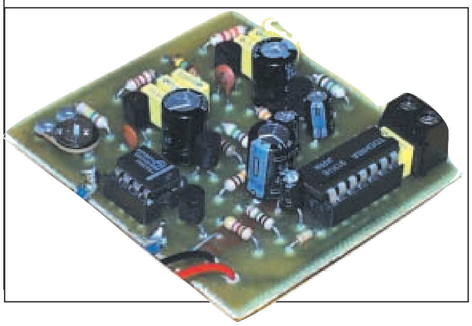
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENTS . . . POPULAR FEATURES . . .

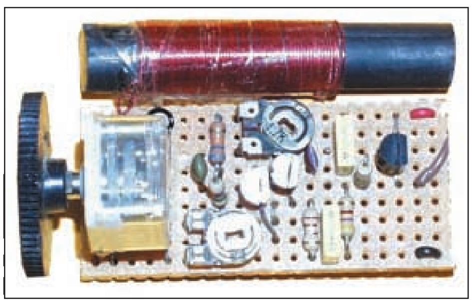
VOL. 32. No. 5 MAY 2003
Cover illustration by jgr22

EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

www.epemag.wimborne.co.uk
EPE Online: www.epemag.com





Projects and Circuits

Series and Features

Regulars and Services

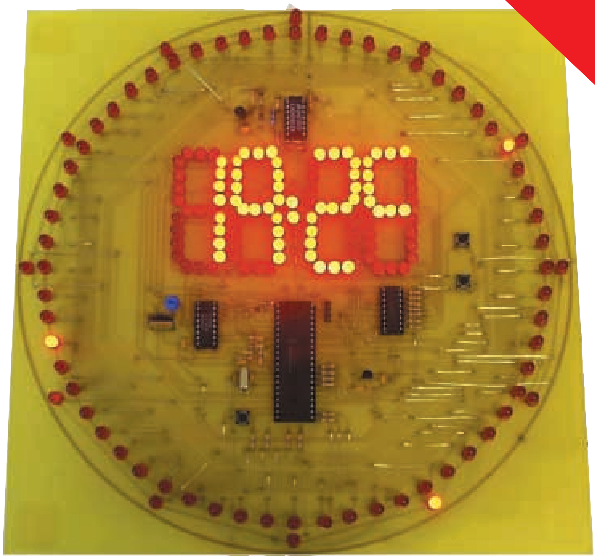
FREE SUPPLEMENT

Our June 2003 issue will be published on Thursday, 8 May 2003. See page 307 for details

NEXT MONTH

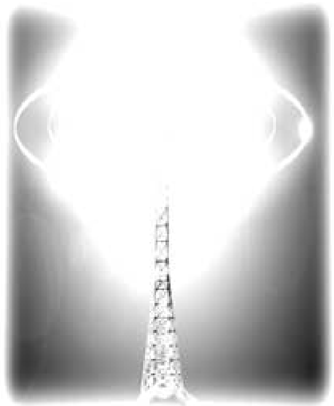
FREE SUPPLEMENT
PIC TUTORIAL V2
Part 3

PICRONOS L.E.D. WALL CLOCK



Inspired by a reader whose giant l.e.d. wall clock had ticked its last tock and could not be revived, this design uses a mixture of ancient and modern techniques, old in the form of l.e.d.s for the display rather than an l.c.d., and modern in the form of a PIC microcontroller (inevitably!). It has the following characteristics:

- *Crystal controlled*
- *Circular display having diameter of 250mm (9·3in.)*
- *Inner ring of 60 l.e.d.s displaying both seconds and minutes*
- *Outer ring of 12 l.e.d.s displaying hours in conventional (analogue) 12-hour format*
- *Inner zone of 100 l.e.d.s in 4-digit 7-segment numerical format, cyclically displaying hours (24-hour format) and minutes, months and days of month, and temperature in degrees Celsius*
- *Powered at 9V to 12V d.c. via a mains supply adaptor, with battery back-up*
- *Adjustable brilliance of the l.e.d. numerals to suit personal taste*



RADIO CIRCUITS

Intended to dispel the mysteries of radio, this short series of articles by Raymond Haigh features a variety of circuits for the set builder and experimenter.

Towards the end of the 19th century, sending a radio signal a few hundred yards was considered a major achievement. At the close of the 20th, man was communicating with space probes at the outermost edge of the solar system. No other area of science and technology has affected the lives of people more completely.

This series will view the technology in a historical perspective and try to dispel its mysteries. The main purpose, however, is to present a variety of practical circuits for set builders and experimenters. You will be able to build a wide range of receivers, everything from a crystal set to a superhet.

FIDO PEDOMETER

Fido's designer enjoys trekking in remote regions where estimating the distance walked can be difficult and retracing steps frustrating! He developed Fido to help solve this problem without the expense of buying a GPS navigational aid. Fido can record the distance traversed by a walker or runner and calculates average speed – a useful addition when planning how long it will take to get back to comfort!

A PIC16F84A microcontroller is employed and the unit can be set to work in miles or kilometres. Clever software allows Fido to be taught to stay at heel – to recognise the length of your stride and keep track of your progress.

NO ONE DOES IT BETTER

EVERYDAY PRACTICAL ELECTRONICS

DON'T MISS AN ISSUE – PLACE YOUR ORDER NOW!
Demand is bound to be high

JUNE 2003 ISSUE ON SALE THURSDAY, MAY 8

EVERYDAY PRACTICAL ELECTRONICS

THE No.1 MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

VOL. 32 No. 5 MAY 2003

Editorial Offices:
EVERYDAY PRACTICAL ELECTRONICS EDITORIAL
WIMBORNE PUBLISHING LTD., 408 WIMBORNE ROAD EAST, FERNDOWN, DORSET BH22 9ND
Phone: (01202) 873872. Fax: (01202) 874562.

Email: enquiries@epemag.wimborne.co.uk
Web Site: www.epemag.wimborne.co.uk
EPE Online (downloadable version of *EPE*)**:** www.epemag.com
EPE Online Shop: www.epemag.wimborne.co.uk/shopdoor.htm

See notes on **Readers' Technical Enquiries** below – we regret lengthy technical enquiries cannot be answered over the telephone.

Advertisement Offices:
EVERYDAY PRACTICAL ELECTRONICS ADVERTISEMENTS
MILL LODGE, MILL LANE,
THORPE-LE-SOKEN, ESSEX CO16 0ED
Phone/Fax: (01255) 861161 Email: epeads@aol.com

TIME OUT

Electronics can do all manner of things, quite often some it should not. During a recent overnight stay in a Travel Inn I experienced an unusual fault with the electronics. The TV set in the room had a built-in l.e.d. digital clock with an alarm facility. I set the alarm for 7.30a.m. and went to bed. As is often the case when sleeping in hotels, I woke up during the night at 4.45a.m. as shown by the clock. On waking again, later, I noted the clock still said 4.45, since it was getting light outside I checked my watch to discover it was actually 6.30. Oh well, the clock had somehow "frozen" at 4.45. However, I was surprised when the alarm sounded at 7.30, even though the display still said 4.45 and, to add to my amazement, when I cancelled the alarm the display returned to the correct time.

Now maybe I'm not being too bright – I certainly was not at 4.45a.m. – but then many readers will have experienced unusual phenomena when working with various circuits.

Cost Engineering

I remember many years ago when working in the RGD/KB development labs in Kent that one engineer was employed to cut the cost of various TV designs before they went into production. I was fascinated to see how many components he could strip out of a new TV circuit design and still get the set to work. Of course, some of the mods resulted in a degradation in performance that was unacceptable, but many seemed to make no difference.

The company also spent a great deal of time testing all sorts of components to see which ones would be the most cost effective in their products. For instance, would it be worth paying for a more expensive potentiometer if a cheaper one would last for a few years – say 10,000 operations – without getting "noisy" or breaking down. Remote control had not made much impact in those days so the on/off volume control would be used quite a bit. Cheaper pots would obviously suffice for lesser used controls like brightness and contrast.

With the massive increase in component reliability and reduction in cost over the years, I guess this type of cost saving engineering is not quite so important today. After all, it costs the same to make a chip containing 10,000 components as it does one with only 1,000 components, once the initial design has been finalised.

Mike Kenward

READERS' TECHNICAL ENQUIRIES

E-mail: techdept@epemag.wimborne.co.uk
We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope or a self-addressed envelope and international reply coupons.**

PROJECTS AND CIRCUITS

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot, however, guarantee it and we cannot accept legal responsibility for it.
A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers (see *Shoptalk*).
We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

ADVERTISEMENTS

Although the proprietors and staff of EVERYDAY PRACTICAL ELECTRONICS take reasonable precautions to protect the interests of readers by ensuring as far as practicable that advertisements are *bona fide,* the magazine and its Publishers cannot give any undertakings in respect of statements or claims made by advertisers, whether these advertisements are printed as part of the magazine, or in inserts.
The Publishers regret that under no circumstances will the magazine accept liability for non-receipt of goods ordered, or for late delivery, or for faults in manufacture.

TRANSMITTERS/BUGS/TELEPHONE EQUIPMENT

We advise readers that certain items of radio transmitting and telephone equipment which may be advertised in our pages cannot be legally used in the UK. Readers should check the law before buying any transmitting or telephone equipment as a fine, confiscation of equipment and/or imprisonment can result from illegal use or ownership. The laws vary from country to country; readers should check local laws.

AVAILABILITY

Copies of *EPE* are available on subscription anywhere in the world (see opposite), from all UK newsagents (distributed by COMAG) and from the following electronic component retailers: Omni Electronics and Yebo Electronics (S. Africa). *EPE* can also be purchased from retail magazine outlets around the world. An Internet on-line version can be purchased and downloaded for just $10.99US (approx £7) per year available from **www.epemag.com**

SUBSCRIPTIONS

Subscriptions for delivery direct to any address in the UK: 6 months £15.50, 12 months £29.50, two years £54; Overseas: 6 months £18.50 standard air service or £27.50 express airmail, 12 months £35.50 standard air service or £53 express airmail, 24 months £66 standard air service or £101 express airmail.
Online subscriptions, for downloading the magazine via the Internet, $10.99US (approx £7) for one year available from **www.epemag.com**.
Cheques or bank drafts (in **£ sterling only**) payable to *Everyday Practical Electronics* and sent to EPE Subs. Dept., Wimborne Publishing Ltd. 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872. Fax: 01202 874562. **Email:** subs@epemag.wimborne.co.uk. Also via the **Web** at: **http://www.epemag.wimborne.co.uk**. Subscriptions start with the next available issue. We accept MasterCard, Amex, Diners Club, Switch or Visa. (For past issues see the *Back Issues* page.)

BINDERS

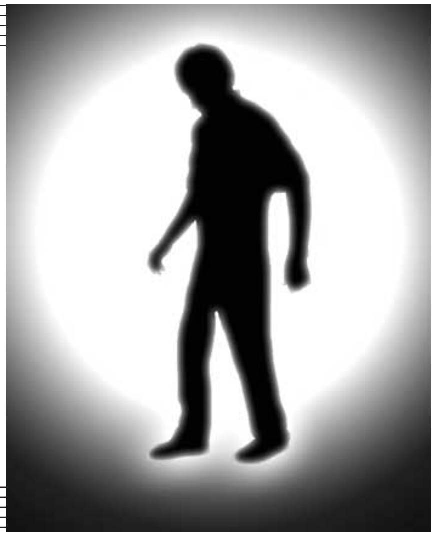
Binders to hold one volume (12 issues) are available from the above address. These are finished in blue p.v.c., printed with the magazine logo in gold on the spine. Price £6.95 plus £3.50 p&p (for overseas readers the postage is £6.00 to everywhere except Australia and Papua New Guinea which cost £10.50). *Normally sent within seven days but please allow 28 days for delivery – more for overseas.*

Payment in £ sterling only please. Visa, Amex, Diners Club, Switch and MasterCard accepted. Send, fax or phone your card number, card expiry date and card security code (the last 3 digits on or just under the signature strip), with your name, address etc. Or order on our secure server via our UK web site. Overseas customers – your credit card will be charged by the card provider in your local currency at the existing exchange rate.

Constructional Project

SUPER MOTION SENSOR

THOMAS SCARBOROUGH



Responds to minute fluctuations in light level. Will detect a single finger moving at 5 metres or a person crossing a path at 20 metres distance.

THE most basic problem with regard to standard light sensors is that these frequently trigger at a specific light level, while what happens in real life is that ambient light levels fluctuate all the time. Therefore a standard light sensor will function correctly only in a controlled environment, or under highly predictable conditions.

The Super Motion Sensor described here, on the other hand, auto-adjusts over the range of about 50 lux to 60,000 lux (that is, a 40W incandescent light-bulb in a $10m^2$ room to direct sunlight). It really "shines", dare we say, in the mid-range of about 100 lux to 10,000 lux (that is, a modestly lit room to bright shade).

It is what is called a "passive" system, in that it does not generate the light which it detects, nor does it use any additional circuitry for this purpose. At the same time, it may be used in the same way as both "active" and "passive" systems.

BRIGHT IDEAS

In daylight, the Super Motion Sensor will typically detect a single finger moving at a distance of 5 metres – *without* the use of any lenses. It will detect a person crossing a path at 20 metres' distance – without lenses.

Under a.c. lighting, it will typically detect a person walking in front of an ordinary light source (e.g. a 60W incandescent light-bulb) at 20 metres – also without the use of any lenses. Note, however, that in this case the sensor is pointed *directly* at the light source, and its range as a "passive" system under a.c. lighting will typically be only eight metres or so.

Generally speaking, a single lens will double these distances, while the use of two lenses, if an "active" system is used, will multiply the basic range by six or seven. With an inexpensive laser diode, a range of hundreds of metres may be achieved.

Since the circuit responds to *fluctuations* in light level, rather than the crossing of a specific light threshold, it is much more flexible than a typical active system. Also, it is not limited to crossing a light threshold in one direction only, e.g. from brighter to dimmer, but may be used in situations of decreasing *and* increasing light.

ENLIGHTENING IDEAS

The Super Motion Sensor has several possible applications and no doubt readers will have their own unique ideas, including possibly some of the following:

It may be used as a "light fence" (or broken beam alarm). However, in contrast to the standard light fence, it requires virtually no set-up. It may simply be placed within the line-of-sight of almost any light source, including vague ambient light, and switched on. It may also be used where a beam is "*un*-broken" – for example, where a computer monitor is blocking a beam, and the monitor is removed.

Since it is not limited to the crossing of a specific light threshold, it will respond to a wide range of variations in light and shadow – for instance, a car entering a driveway, a person moving in a room, or wind rustling the leaves of a tree.

The author's original interest came from a three-wheel vehicle which he drove. This vehicle had an open cab, which seemed to invite all-comers to climb into it and play with the controls. In one case, a young boy let off the hand-brake and went careering into a tree! How could the vehicle sense, from a good distance, whether anyone was approaching?

With two light sensors mounted in the roof framework of the cab, one at each side of the vehicle, and "looking" down onto the pavement through plastic tubes, these detected feet moving over a wide range of lighting conditions. The circuit in turn triggered a spoken message – which, alas, seemed to attract yet more curiosity!

In a similar way, the Motion Sensor may be placed in luggage that needs to be protected in a public place, with a light sensor "looking" upwards over a suitable angle. If anyone should reach for the luggage, or stoop over it, or move it, an alarm would be triggered. Moreover, it would continue to trigger as long as the luggage was in motion.

Lastly, it may be used to detect *direction* of movement. If one refers to the author's *Big-Ears Buggy* project (*EPE*, Aug. '02), the two front-end preamplifier stages in that circuit may be replaced with two Super Motion Sensors, with the outputs of the "Sensors" being taken, in each case, from IC3 pin 6 to resistors R15 and R16 of the *Big-Ears Buggy*. In this case – as an example – a person entering a building would be detected, but not a person exiting.

the values of the capacitors were increased, this would further extend the time periods involved. A fire alarm system typically triggers when it detects a rise of 22°C per minute, while the Super Motion Sensor will potentially detect a change of just a fraction of 1°C. (A terrific Temperature Tracker, perhaps?).

When the charge on the capacitor (the potential) at the comparator's inverting (–) input rises higher than that at the non-inverting (+) input, or when the potential at the non-inverting input falls below that of the inverting input, the comparator's output goes "low", thereby triggering a monostable timer and a relay.

As with any detection circuit, there are certain physical variations which the circuit should detect, and others which it should exclude. Perhaps the most important exclusion in this case is natural variations in ambient light – such as sunrise, sunset, or the shadows cast by clouds. This the Motion Sensor achieves by comparing variations in light level at a speed that is *almost* too fast for it to detect slower, natural variations. Unless the circuit is set very sensitively, these are excluded.

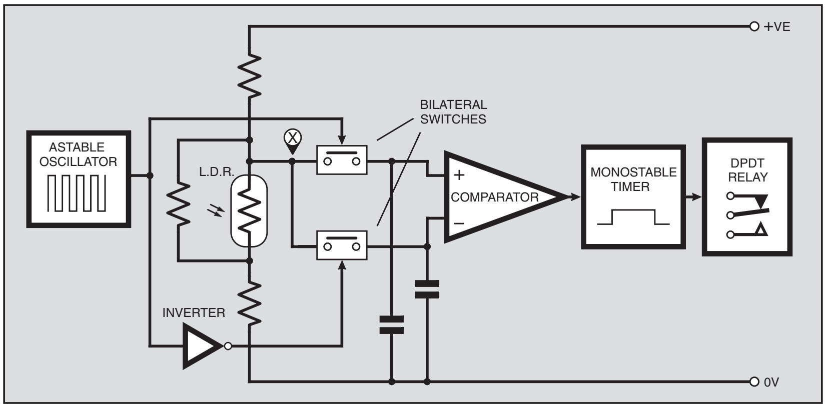


Fig.1. Simplified block schematic diagram of the Super Motion Sensor.

HOW IT WORKS

Block diagram Fig.1 is a simplified representation of the circuit, and gives a good overview as to how the Super Motion Sensor works.

A light dependent resistor (l.d.r.) is so wired in conjunction with the three resistors shown that, between darkness and full sunlight, it offers a potential at point *X* of between roughly one-quarter and three-quarters of the supply voltage. This potential is presented simultaneously to the inputs of two bilateral switches.

An astable oscillator, together with an inverter, switches the two bilateral switches alternately, typically at a few Hertz, so that the two capacitors are alternately charged. Since the resistance of the bilateral switches in the "off" state is very high, and the input impedances of the op.amp comparator very high, the charge on the capacitors is "trapped" in the spaces between the bilateral switches and the comparator. This will ordinarily vary very little during switching. These are referred to as sample-and-hold circuits.

So little, in fact, does the charge on the two capacitors vary over time that the astable oscillator could easily be slowed, and the l.d.r. replaced with a thermistor. If

Miniature light dependent resistor (l.d.r.), about twice size, clasped between thumb and finger.

While still on the *concept* of the Super Motion Sensor, a difficulty arises when a.c. lighting is used, as it does with most light sensor circuits. This is because a.c. lighting fluctuates at a rate of 50 cycles per second (60 in the USA), and while the eye does not normally see this, due to persistence of vision, the fluctuation or flicker of a.c. lighting can be sufficient to trigger the circuit. The more the light flickers (e.g. fluorescent lighting), the greater the difficulty this presents.

DANGER LEVEL

A simple solution is given later with the circuit shown in Fig.2 – but consider for a moment a more sophisticated alternative (this was *not* incorporated in the present design, since it would have made it an "experienced constructors only" project). **The following should under no circumstances be tried unless the constructor is experienced with circuits that are connected to the mains. Mains electricity can kill you.**

Consider that the two bilateral switches receive their timing from the a.c. mains rather than the astable oscillator incorporated in the circuit. This would cause the circuit to switch in sympathy with fluctuations in a.c. lighting, thus making it virtually completely immune to 50Hz flicker (60Hz in the USA). Sensitivity under a.c. lighting would be significantly increased, and the need for any readjustment when moving the circuit from natural lighting to a.c. would be obviated.

The author tested this successfully by connecting a low voltage pulse derived from the a.c. mains supply to the control pins of the bilateral switches. In this case, the link wire adjacent to pin A (Fig.4) is removed from the printed circuit board (p.c.b.), and the peak voltage pulse is adjusted to just below 12V.

This last concept opens the possibility of a Defective Lighting Detector. If a.c. lighting should waver or become defective, the Super Motion Sensor would immediately pick this up. The author's prototype picked up several "brownouts" (voltage/lighting drops) during testing.

ANALOGUE vs DIGITAL

Originally, the author took a *digital* approach, translating light level to binary numbers, then making a binary comparison over time. This was done by converting the resistance of the l.d.r. to frequency, and the frequency to binary numbers. If a series of binary comparisons showed themselves to be unequal, then a motion was detected.

This approach, however, ran into an unthought-of hitch. In order to obtain two binary numbers which were sufficiently accurate to compare reliably, at high sensitivity (thus obtaining an equal result if the light level remained constant), a high degree of timing accuracy was required. While this would not have been too difficult to achieve, it would have considerably complicated the circuit.

Another problem presented itself with this approach, in that if a relatively constant light level caused the least significant binary digit to switch between a 0 and a 1, or to vacillate between the two, this gave the illusion of detection having taken place. A solution which was tried successfully was to make a *series* of binary comparisons instead of only one.

The present analogue approach, besides avoiding these difficulties, obviates the need for three or four digital i.c.s. or a microcontroller at the core of the circuit.

CIRCUIT DETAILS

We are now in a position, we might say, to "shed more light" on the full Super Motion Sensor circuit – see Fig.2.

One half of a 7556 CMOS timer i.c. (IC1a) is wired as an astable oscillator, and, with the help of IC2c, configured as an inverter, this is used to switch bilateral switches IC2a and IC2b alternately. This circuit configuration is seldom seen, due

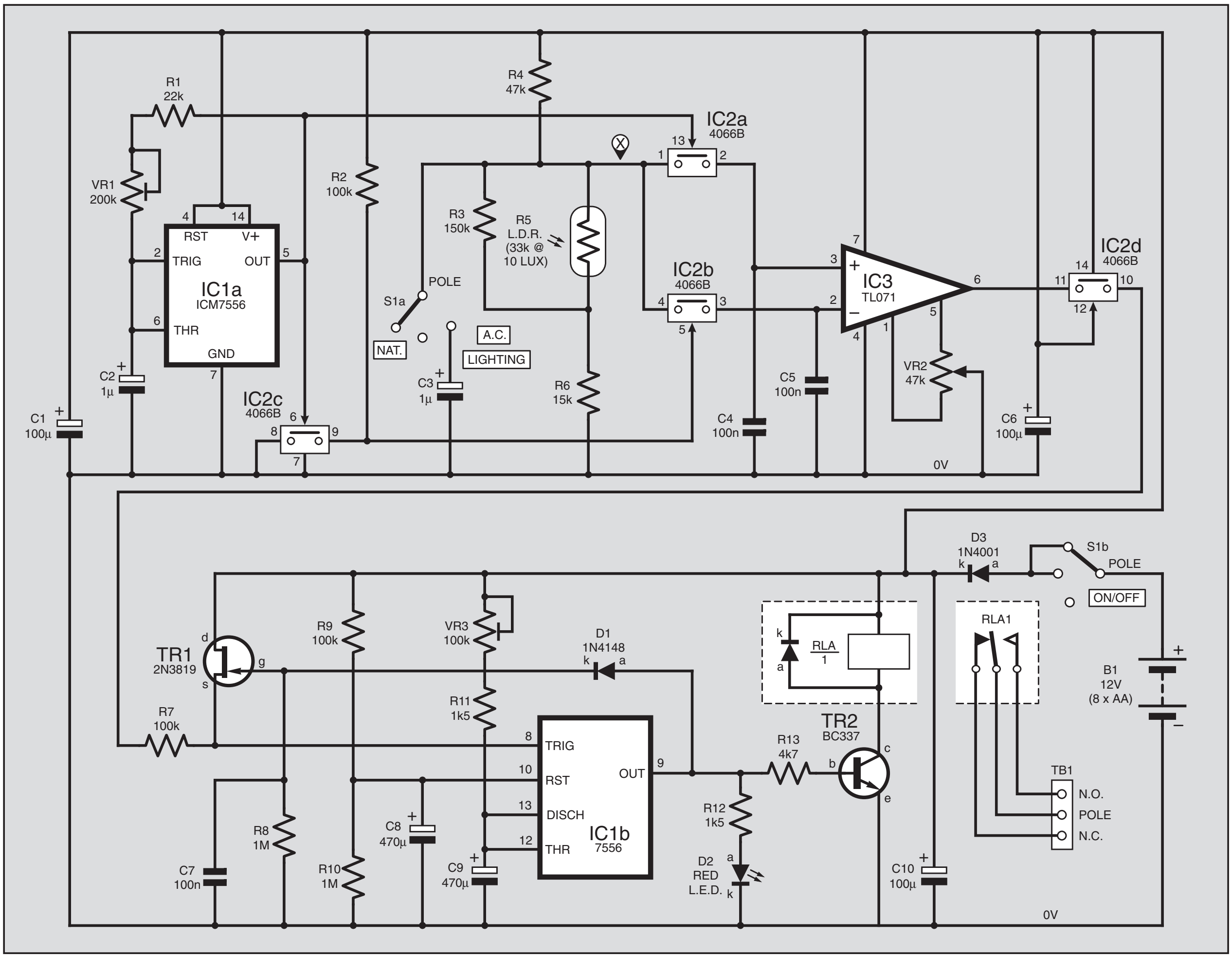


Fig.2. Complete circuit diagram for the Super Motion Sensor.

probably to its inability to be more than lightly loaded without disturbing the timing. However, in this case IC2's control pins have a very high input resistance, and this configuration represents an easy means of obtaining the required 1:1 mark-space ratio which the "orthodox" configuration does not so simply provide.

Potential divider network R3 to R6, including the l.d.r., provides the required potential at point *X* to charge capacitors C4 and C5 through the bilateral switches. The values of R3, R4 and R6 are chosen so that, regardless of the light sensor used, the potential at point *X* stays between 24% and 78% of supply voltage. This means that a wide variety of sensors may be used in place of the specified l.d.r., including phototransistors, photodiodes, and infrared and ultra-violet devices.

INTERCHANGE

Although l.d.r.s have slower response times than other devices, an l.d.r. was chosen here because it may easily be interchanged with similar devices of the same family. This is not always the case with phototransistors and photodiodes, which have some awkward relatives. Note that if a photodiode is used, the cathode (k) would normally be wired to the junction of R3 and R4. An l.d.r. is completely non-polar.

Consider now that if the light level remains constant over time, there will be a similar charge on capacitors C4 and C5. However, if the light level *changes* over time, one of the two capacitors will retain a higher or lower charge than the other. This triggers op.amp comparator IC3 (that is, it goes "low" at its output).

Strictly speaking, the comparator triggers only if the voltage at the inverting input rises above that at the non-inverting input – i.e. if the voltage at the inverting input rises, or if the voltage at the non-inverting input falls. However, bear in mind that every increase in light level is followed by an attendant decrease and vice versa, so has little consequence in practice.

The two bilateral switches, IC2a and IC2b, are switched between about 3Hz and 30Hz, depending on the setting of preset VR1. Faster switching will mean smaller differences in charge between C4 and C5 (thus lesser sensitivity), but will react more readily to faster fluctuations in light level. Slower switching will mean the opposite, and would make the circuit a little more sensitive to natural variations such as moving clouds. Preset VR1's mid-position should suit in most cases.

ROUGH AND READY

With regard to a.c. lighting, the present circuit offers a rough and ready solution in the form of smoothing capacitor C3 at point *X*, which smooths out the worst of a.c. flicker. A necessary result of this, unfortunately, is some loss of sensitivity, although it does present a reasonably good solution. For particularly bad lighting situations, the value of C3 may be increased.

Op.amp comparator IC3 was chosen particularly for its high input impedance, which is necessary so that capacitors C4 and C5 should retain their charge. It was also chosen specifically for its provision of an offset-null, which is used to balance the differential input stage so that the inverting input is normally "higher" than the non-inverting input.

Failing this, the potentials at the two inputs would be "too close for comfort", and might or might not trigger IC3. A method that is frequently used to "balance" such circuits is a potential divider at the inverting input, but for a number of reasons, this is less satisfactory.

SENSE OF AMBIENCE

Bilateral switch IC2d represents another circuit option. As it stands, IC2d has its control pin (12) wired to the positive rail, so that the corresponding bilateral switch will always conduct.

However, if IC2d pin 12 were taken to a potential divider incorporating a second l.d.r., as shown in Fig.3, IC2d could be used to disable the Motion Sensor as ambient light levels either increased or decreased.

As shown, the circuit is disabled with increasing light level. If R1 and VR1 were swapped around with the l.d.r., the circuit

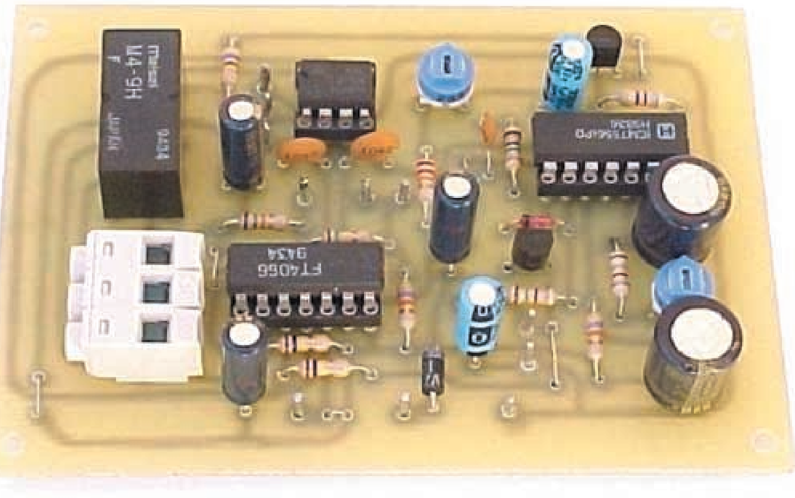
would be disabled with *decreasing* light level.

EXTREMELY SENSITIVE

The present circuit is one of extreme sensitivity, and the first stages especially require "quietness" to function properly. Therefore, no l.e.d. is used to display the switching action of IC1a (although this might be helpful). Also, no l.e.d. is used to show the state of the output of IC3. A relatively small value is chosen for timing capacitor C2, and supply decoupling is employed throughout (C1, C6, and C10).

A special problem presents itself, however, in the form of relay RLA. This carries a relatively heavy current when switched by monostable IC1b, and would ordinarily upset the circuit and reduce its sensitivity.

This problem is overcome by "blanking" the relay's action through transistor TR1, which disables the trigger input (pin 8) of timer IC1b, allowing a short period (a fraction of a second) for the circuit to settle after relay RLA has disengaged. At the same time, l.e.d. D2 is included in this blanking, so that it, too, may not upset the normal operation of the circuit.



Layout of components on the completed circuit board. The relay can be seen top left.

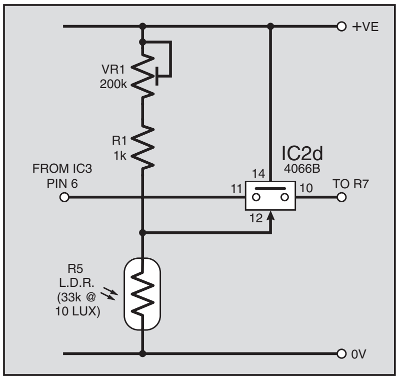


Fig.3. Circuit addition, using a second l.d.r., to achieve daytime/night-time switching.

The blanking action works as follows: When the output of IC1b goes "high", capacitor C7 is charged, and TR1's gate is held "high". This means that it conducts, and the potential at the junction of TR1 source and R7 is also high.

Therefore, with trigger pin 8 being held "high", this is disabled for a moment, giving the circuit time to settle after relay RLA has disengaged. Capacitor C7 discharges mainly through resistor R8.

Current consumption of the circuit is less than 10mA on standby, so that battery operation (e.g. 8 × AA batteries) is feasible.

CONSTRUCTION

The Super Motion Sensor is built on a printed circuit board (p.c.b.), measuring 65mm × 95mm. The topside component layout and full-size underside copper foil master are shown in Fig.4. This board is available from the *EPE PCB Service*, code 391.

Begin construction by soldering in position the three dual-in-line (d.i.l.) sockets and the board lead-off solder pins. This should be followed by the resistors, capacitors and the preset potentiometers VR1 and VR3. Next, the diodes D1, D3 and the two transistors should be inserted on the p.c.b., paying particular care to their polarity.

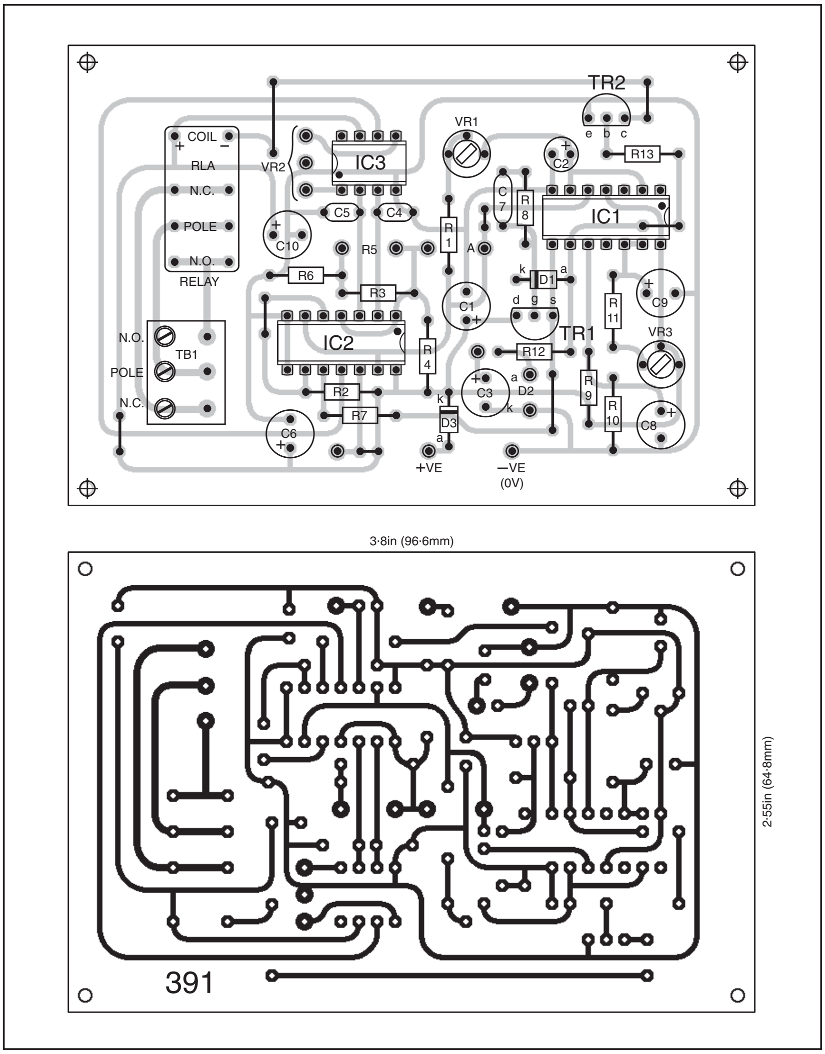


Fig.4. Printed circuit board topside component layout and full-size underside copper foil master pattern for the Super Motion Sensor.

Finally, the relay and the three-way terminal block should be installed on the board.

Use suitable lengths of connecting wire to wire up the off-board components VR2, l.e.d. D2, slide switch S1 and the battery clip. The author used a length of 8-way ribbon cable to provide a neat result.

LIGHT SENSOR

When an l.d.r. is in its "naked" state, it has a very wide viewing angle, and its sensitivity is low. The sensitivity may be greatly enhanced by making it "look" down the length of a narrow, black tube (see Fig.5 and photograph). In this way

the distances described earlier were achieved.

The tube may be cut from the shaft of a felt pen. The leads of the l.d.r. are then stuck through a small, firm piece of foam rubber (not conductive foam rubber!), soldered to a suitable length of "twin-flex" wire, and pushed into the tube.

Epoxy glue is used to set the whole in place, and a rubber grommet may be added to the case for neatness. The sensor is then soldered to the p.c.b. as shown in the interwiring diagram Fig.5.

COMPONENTS

See SHOP TALK page

Resistors
- R1 — 22k
- R2, R7, R9 — 100k (3 off)
- R3 — 150k
- R4 — 47k
- R5 — min. light dependent resistor (l.d.r.), 33k @ 10 lux (or similar – see text)
- R6 — 15k
- R8, R10 — 1M (2 off)
- R11, R12 — 1k5 (2 off)
- R13 — 4k7

All 0·25W 5% carbon film, except R5

Potentiometers
- VR1 — 200k cermet preset
- VR2 — 47k rotary carbon, linear
- VR3 — 100k cermet preset

Capacitors
- C1, C6, C10 — 100µ radial elect. 16V (3 off)
- C2, C3 — 1µ radial elect. 16V (2 off)
- C4, C5, C7 — 100n ceramic disc (3 off)
- C8, C9 — 470µ radial elect. 16V (2 off)

Semiconductors
- D1 — 1N4148 signal diode
- D2 — 5mm ultrabright red l.e.d.
- D3 — 1N4001 50V 1A diode
- TR1 — 2N3819 *n*-channel field effect transistor
- TR2 — BC337 *npn* medium power transistor
- IC1 — 7556 CMOS dual timer
- IC2 — 4066B quad bilateral switch (or equivalent)
- IC3 — TL071CN j.f.e.t. op.amp

Miscellaneous
- S1 — 2-pole 3-position slide switch
- RLA — 12V coil, p.c.b. mounting relay, Telecom type with built-in protection diode (see text)
- TB1 — 3-way, p.c.b. mounting, terminal block, 5mm pitch

Printed circuit board available from the *EPE PCB Service*, code 391; ABS plastic case, size to suit; 8-pin dual-in-line (d.i.l.) socket; 14-pin d.i.l. socket (2 off); calibrated knob; black plastic tube for l.d.r. housing (see text); 8 x AA battery holder; battery clip; 8-way ribbon cable (optional); "twin-flex" wire; link wire; solder pins; solder, etc.

Approx. Cost Guidance Only **£15** *excl. batts & case*

CASING-UP

Once soldering is complete, insert the i.c.s in the d.i.l. sockets, observing the correct orientation (note: these are orientated differently). Note that IC1 and IC2 are CMOS devices, and require care when handling (first discharge your body to ground). In the author's experience, j.f.e.t. TR1 is also more fragile, and it, too, requires some care.

Mount the Sensitivity control VR2, l.e.d. D2 and slide switch S1 on the case base; now the top. The constructor might also wish to replace presets VR1 and VR3 with shafted potentiometers, and mount these on the case for easy adjustment. The p.c.b. was mounted on the lid (bottom) of the case, and a partition was slotted into the case to hold the batteries.

While the circuit diagram Fig.2 shows a 12V power supply, the circuit may also be powered off 9V if desired. Note that the relay's voltage rating will need to match the supply voltage. Alternatively, a lower voltage rating may be used for the relay (e.g. 5V), if the link wire at TR2's collector is replaced with a suitable resistor.

If in doubt, use a one kilohm (1k) preset potentiometer here wired as a variable resistor, beginning at 1k and turning it back until the relay triggers in sync with l.e.d. D2. The preset may then be replaced with a fixed resistor.

Generally speaking, a Telecom relay (for which the p.c.b. is designed) will carry about 60W across its switching contacts – but check specifications first.

The author used an ultrabright red l.e.d. for D2, so that the circuit could be tested at a distance. In some cases, the range of the circuit is such that an ordinary l.e.d. may not be seen without binoculars!

A p.c.b.-mounting terminal block is used to connect the unit to external circuits (e.g. a siren). The provision of "blanking", as described earlier, enables one to run such circuits off the Super Motion Sensor's own power supply.

CALIBRATION AND USE

Commence the setting up of the Sensor by turning preset VR1 and potentiometer VR2 to their mid positions, and turn preset VR3 back (anticlockwise) completely, then switch on – selecting natural or a.c. lighting with switch S1.

The circuit will take a few seconds to settle and come to life, as capacitor C8 charges and IC1b's reset pin goes "high". L.E.D. When VR2 is suitably adjusted, D2 should illuminate and the relay click as a hand is moved over the l.d.r.

If l.e.d. D2 illuminates repeatedly, turn back VR2 (anticlockwise). If it does not illuminate at all, turn it up (clockwise).

If the circuit does not work as described, immediately switch off and disconnect the power, and carefully re-check. Ensure that there are no solder bridges on the p.c.b., that all components are inserted correctly, and that all interwiring is correct.

Once it has been established that the circuit is working, presets VR1 and VR3 may be further adjusted. The function of VR1 has been described above. Preset VR3 adjusts the trigger period of monostable IC1b and thus the "on" time of the relay between about half a second and 30 seconds.

The Super Motion Sensor will work best in situations of good contrast (e.g. shadows on a white wall). It would be best to adjust it to a little less than its maximum sensitivity.

What ultimately matters is that it should exclude any variations in light level that might cause unwanted triggering – e.g.

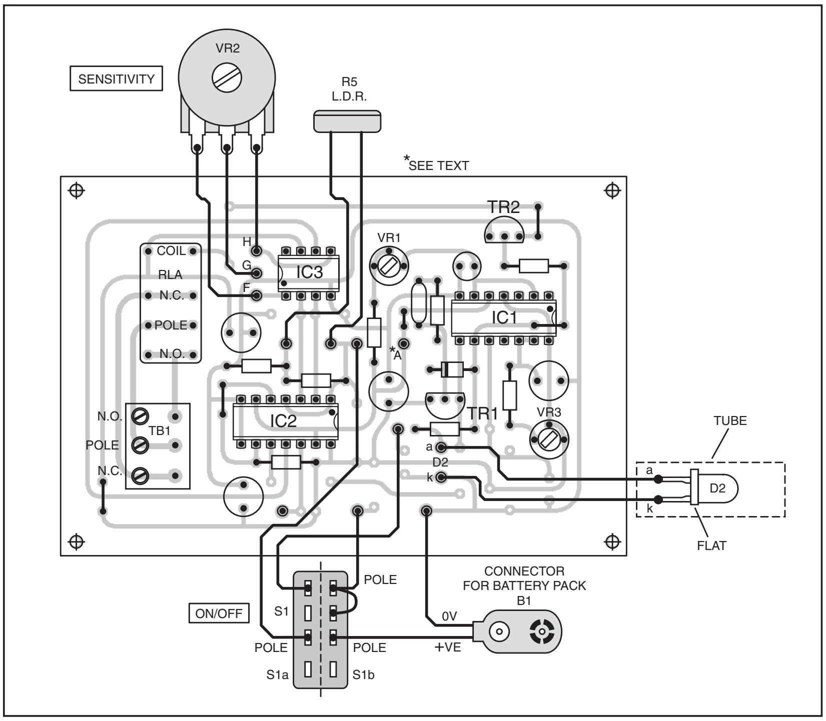
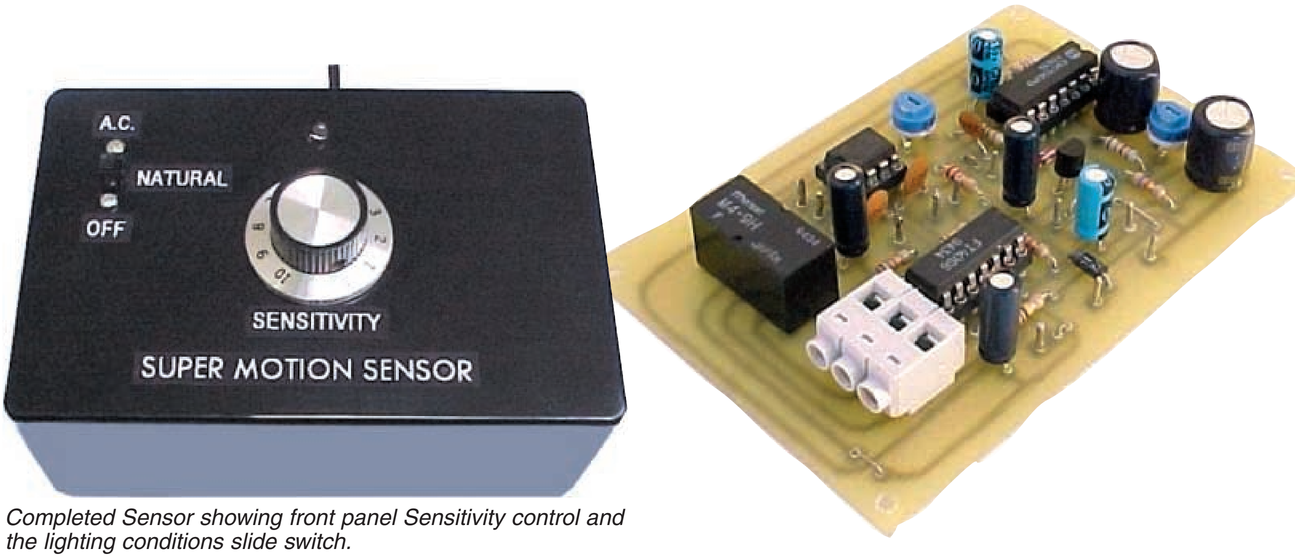


Fig.5. Details of the interwiring from the circuit board to off-board components. Note that the On/Off slider switch contact line-up may differ to that shown.



Completed Sensor showing front panel Sensitivity control and the lighting conditions slide switch.

birds flying past, leaves fluttering, or cloud movements. Even if sensitivity is reduced by, say, one-quarter, the circuit remains unusually responsive.

With some experimentation, it may be set to transition seamlessly from Natural to A.C. lighting – but this, unfortunately, will not occur at maximum sensitivity for both.

If maximum sensitivity under natural lighting triggers the circuit under a.c., then adjust for maximum sensitivity under a.c. – and vice versa. □

May 2003 – Special PIC Supplement

This special 16-page supplement is available for free download from the EPE Online website.

All you have to do is bounce over to www.epemag.com and click on the “Library” link in the main navigation.

TECHNO-TALK ANDY EMMERSON

Tiny Tags Talk Volumes

Barcodes are set to disappear! Andy Emmerson explains.

FOR many people (including the author!) "retail therapy" is an ideal means of lifting the spirit but even then the pleasure can easily vanish when faced with a long checkout queue and a barcode scanner that refuses to recognise product codes. At this stage cashiers tend to panic and call for assistance leaving shoppers to seethe while the queue that they haplessly chose is log-jammed.

Barcode scanning may soon be a thing of the past, however, if the current plans for r.f. tagging keep to schedule. And time is at the heart of this story simply because time is money to retailers.

Barcodes take time to scan, simply because they have to be passed manually in front of a scanning device. The more goods you are buying, the longer the process is and the slower the transaction. Obvious that may be but it's also highly relevant to supermarket customers in a hurry to get home at 6pm on a Friday evening.

TOUCHLESS TECHNIQUE

A far better solution would be one in which each product you have bought "told" the till its details without prompting or handling. The same applies to luggage transiting airports, and commuters boarding buses or trains in the rush hour. For all of these a touchless solution would be far preferable.

Commuters are lucky. In several major cities season ticket holders now have a radio-activated pass that needs only to be waved near a sensor (no more shoving tickets into slots). The same technique is used to protect high-value goods in retail stores; try walking out of a clothing store with an unpaid-for garment, then stand by for action as the alarm goes off.

All of these systems rely on tuned radio circuits embedded in tags or tickets detuning a low-power radio frequency field. The same principle underpins the new RFID (radio frequency identification) tags proposed to replace barcodes on retail goods and travellers' baggage.

Applying an RFID tag to every product out on the shelves is the retailer's ultimate dream, a concept endorsed at the annual Retail Automation Conference in London last autumn. At this stage the cost of the tags and the new equipment to interrogate them is still prohibitive but this is set to plummet as the idea catches on. Unified standards need to be drawn up too before the practice becomes commonplace or even universal, but the idea is to create a single, globally recognised numbering scheme similar to the universal product code employed on barcodes now. There are also data privacy issues to be resolved if retailers associate RFID tag data with customers' loyalty card details.

One firm that has committed to RFID tagging is personal hygiene manufacturer Gillette, which has purchased 50 million tags for use in the UK and USA. Tesco is its first retail partner and will trial tagged Gillette products in Cambridge. Other early adopters, such as Woolworths in the UK and the GAP fashion stores in the USA, have already conducted trials and seen the merits of the system. Data accuracy is stated as 99·7 per cent, far better than previous systems, and the feeling is that companies should concentrate on the benefits rather than the cost.

FOOD CHAIN

Even if you do not spot RFID tags immediately in your local supermarket, that does not mean the idea has failed. They will still be used for coding products by the crate or tray load further back in the food chain, for instance at Marks & Spencer. The upmarket retailer recently announced the world's largest rollout of RFID tagging, with a scheme to tag 3·5 million food trays passing through its warehouse and distribution system.

As pallets or cases of goods leave one location for another, they will pass readers that will pinpoint the progress of each and every consignment. As well as helping pinpoint slow-moving inventory, the system will also provide automatic proof-of-delivery at each point along the line of route, assisting both Marks and their suppliers. "Stock shrinkage" (*theft* to the rest of us) will be reduced too, as it will be possible to spot the exact stage where items go missing. The same technique is already in use in parts of the automotive industry.

The savings suppliers make can be passed on to consumers and there are other end-user benefits too. Greater information capture means better stock control; wastage will be reduced and shelves should never go empty under normal conditions. It will also be easier to identify, in real time, batches of products that need to be recalled or replaced for any reason.

TECHY STUFF

So much for the benefits, how exactly do RFID tags work? Tags can be active (with an integrated battery) or else passive (deriving energy from the r.f. field generated by the reader). Active tags have longer range and can transmit more information but carry a heavy cost penalty. Passive tags are much lighter, less expensive and should last more or less forever.

A company in the USA, Allen Technology, produces a read-only tag with 64-bit memory weighing 25 grams. It operates on 915MHz, a licence-free band for industrial, scientific and medical purposes in North America (used for cellular radio here in Europe). Another US firm, Matrics, also uses this band; its products have a read range of three metres and the product is totally tamperproof.

In Europe Philips has joined forces with Tagsys to develop a low-cost smart label system operating at 13·56MHz. These tags, which are similar in size to the sticky label security tags already used to prevent theft, incorporate tiny i.c.s made by Philips, used with r.f. equipment made by Tagsys, and can be read at a rate of 150 items per second.

The actual data that can be contained in RFID tags is awesome and far greater than the humble barcode can carry. Tags applied to some EMI CD albums already state a global product identification code that embraces their origin and final retail destination. This is only the tip of the proverbial iceberg and the data has the potential to document a complete product history, including date and place of manufacture, ownership and far more.

READY FOR TAKE OFF

There is a general agreement that RFID tagging will take off when the cost of the tag drops to one per cent of the cost of the product it is applied to, and that date is still some way off. Semiconductors made of organic materials are cited as one way of reaching this price break but the jury is still out on the feasibility of the manufacturing process. It is, nonetheless, a matter of when rather than whether, simply because the benefits are so attractive.

A report by analysts AMR Research indicates that early adopters have reaped cost savings equalling five per cent of sales turnover, an advantage not to be sniffed at. 2005 is the date that the research firm says when r.f. tagging becomes viable and until then we must wait and see.

Ancient Optical Comms

Mechanics' Magazine 7 January 1826 describes an ingenious "Gas-Light Night Telegraph" which, despite thoughts to the contrary, was not an April Fool project.

Six gas lanterns were arranged in a triangle and could be illuminated or extinguished rapidly by opening and closing gas taps to the main supply, concealed pilot flames doing the actual lighting. Combinations of lamps lit would indicate letters of the alphabet, rather as pointing needles did in the electric telegraphs of Cooke and Wheatstone that followed soon afterwards – and rendered this form of optical communication still-born.

News . . .

A roundup of the latest Everyday News from the world of electronics

ATRAC-TIVE MUSIC SNACKING

Barry Fox highlights Sony's system that can rip 30 music CDs onto one.

SONY has announced a major modification of the CD system which lets home copiers rip at least 30 music CDs onto a single blank CD, and play the music back on a £100 portable stereo.

Sony's system, to go on sale in May, uses Atrac3Plus, a much improved version of the ATRAC compression system which Sony developed ten years ago for Mini Disc. Now that the patents on CD have run out, Sony is free to adapt ATRAC for use with CD. Sony has coined the phrase "music snacking" because one disc can hold enough different music to satisfy every taste or mood.

By analysing the music in 52 separate frequency bands before converting it into digits, and then tweaking the digits, ATRAC records stereo onto a blank CD at 48Kbps, which is around a third the amount of data needed for MP3 and one thirtieth the amount used for CD. So one blank CD, costing a few pence, can now hold 30 hours of music.

Sony's new ATRAC CD Walkman will start at under £100 and play either the new home-recorded 30 hour discs, or conventional CDs, or MP3 discs. The price includes free ATRAC compression software, called Sonic Stage "Simple Burner", that lets a home computer do the recording.

The player comes with rechargeable batteries which allows up to 150 hours playing time. This, reminds Sony, is "enough to fly to Australia and back three times".

Sound quality will be acceptable for people who are used to listening to MP3.

Jack Rabbit

Philips, the company which jointly owned the patents on CD, is doing things differently. Philips' new DVD PC burner works at four times normal speed to record music in MP3 format onto blank DVDs – which hold at least seven times as much music as a blank CD. The MP3 DVDs then play back on a portable DVD player called Jack Rabbit, costing around £200.

News of both developments came as a surprise to the music industry's trade bodies, the International Federation for the Phonographic Industry and Recording Industries Association of America. But both bodies were surprisingly sanguine. The RIAA did not feel the need to make any comment and the IFPI says its faith is in "the availability of legitimate on-line music services". These, the IFPI hopes, will encourage people to buy music instead of copying it for free from CDs or unauthorised Internet sites.

Less surprising, Sony Music also refused to comment.

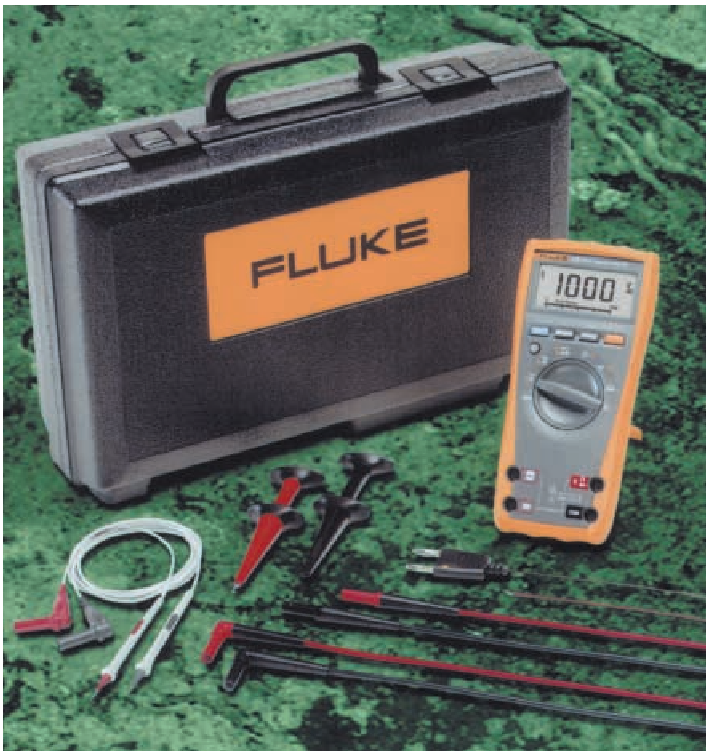
SAVE WITH FLUKE

FLUKE is offering a 24% saving when purchasing their Combo Kit. This includes the top of the range 179 DMM, which is a true r.m.s. meter, an integrated temperature probe, set of silicon test leads and hook clips, and alternative leads with special electronic test probes.

The meter offers 0·09% basic d.c. accuracy, has a large easy to read 6000 count backlit display and features an analogue bargraph. Frequency, capacitance and resistance ranges are up to 100kHz, 10,000μF and 50MΩ respectively. Temperatures up to +260°C can be read with the plug-in Fluke 80BK thermocouple probe.

In addition the meter offers enhanced troubleshooting features, which include Min/Max/Avg recording, with an audible warning, AutoHold and Display Hold. A set of the latest 1·5m long SureGrip silicone test leads are included, plus a meter and accessory case, a pair of test probes offering 1mm replaceable steel and spring loaded gold tips, and a hook set with a 6·4mm opening.

The suggested retail price for the kit is £188, representing a 24% saving over the purchase of the individual items. It is available from authorised Fluke distributors. Browse **www.fluke.co.uk**.



ALLIGATOR CLIPS

POMONA Electronics have introduced a complete family of flexible boot alligator test clip products. They have a CAT III 1000V 10A rating and are adaptable to meet a variety of test needs, attaching to terminals up to 7·6mm o.d.

Pomona's offering includes two probe tip adapters, two patch cords and one alligator clip for test lead attachment. The probe adaptors interface to standard 2mm and 4mm lantern tip DMM probes. The patch cords include alligator-to-alligator, and alligator-to-rightangle sheathed banana plug and are offered with flexible heat resistant silicone wire.

For more information browse:
www.pomona.cc and **www.pomonaelectronics.com**.

OUT THE WINDOWS

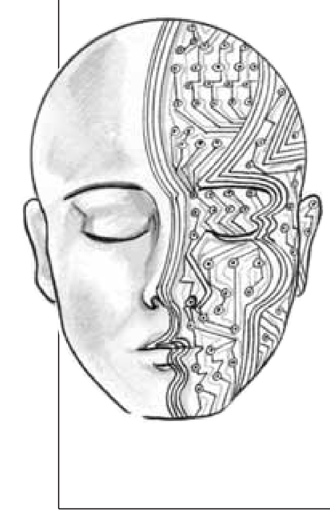
By Barry Fox

NOT everyone wants Windows. In October '02, Microsoft and Orange staged a mega event in London to announce the world's first Windows-powered Smartphone service. SPV will offer Sound, Pictures and Video on the move for 40 million Orange subscribers in 21 countries, using GPRS cell-phones with the Windows operating system and Internet Explorer. The Orange phones are made under contract in Taiwan by HTC.

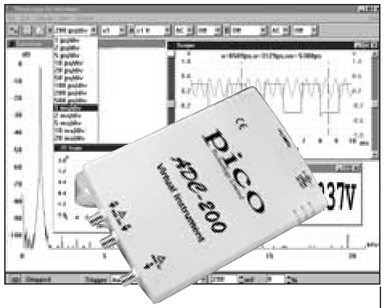
At the launch Microsoft and Orange proudly announced outside support from Sendo, the go-getting cell-phone company started by ex-Philips management and now selling high spec, low cost phones in over twenty countries in Europe and Asia. Sendo was at the Microsoft event to show off the Windows-powered Z100 "world's smartest phone". But now Sendo has dumped Microsoft Windows and switched to the rival Nokia/Symbian operating system.

Sendo says that "for legal reasons" it cannot say why it canned the deal with Microsoft, just weeks before launch of the Z100. But a spokeswoman confirms that Sendo now wants to work with a company which lets its partners work with the source code. Microsoft won't, Nokia will.

INGENUITY UNLIMITED



Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.** Send your circuit ideas to: *Ingenuity Unlimited,* Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown Dorset BH22 9ND. (We **do not** accept submissions for *IU* via E-mail.) Your ideas could earn you some cash **and a prize!**



WIN A PICO PC BASED OSCILLOSCOPE WORTH £586

- 100MS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter ● Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours. Every 12 months, Pico Technology will be awarding an ADC200-100 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £69 will be presented to the runner up.

Fully Automatic Egg Timer – Just White

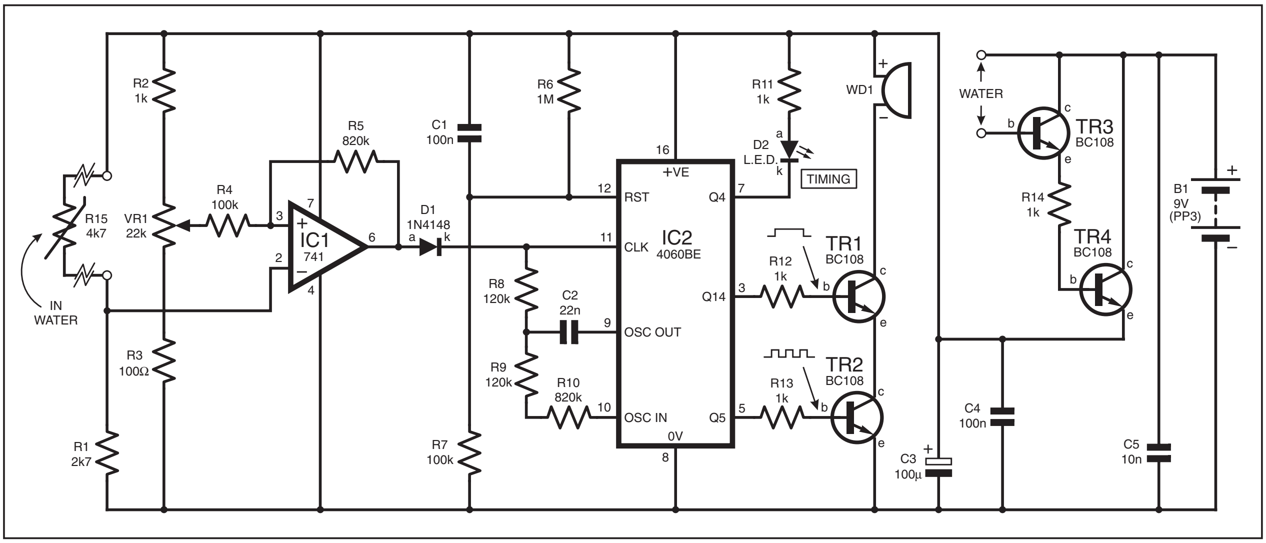


Fig.1. Complete circuit diagram for the Fully Automatic Egg Timer.

ONE of the most tasty and natural sources of protein is without doubt the humble boiled egg, however desirable results can often be difficult to attain (i.e. solid egg white and liquid yolk) without prior experimentation. Egg connoisseurs everywhere will appreciate the inexpensive circuit of Fig.1, which produces almost perfect results with a wide variety of pan sizes, water volumes and heat rates.

Egg Thermidor

Thermistor R15 is placed in the pan of water and forms a bridge arrangement with resistors Rl, R2 and R3 and potentiometer VR1. A low value of 4k7 has deliberately been chosen for R15, so that in the event of water breaching the seal around its leads, the resistance of the water (approx. 50k) in parallel with it will have minimal overall effect.

Op.amp IC1 operates in comparator mode, with resistors R4 and R5 providing hysteresis in order to ensure a clean switching action. Potentiometer VR1 is set so that when the water reaches 70°C, the point at which the eggs actually begin to cook, IC1 is triggered and a logic 1 appears at its output.

Consequently, pin 11 of a 4060 ripple counter IC2 is now at logic 1 and a countdown of four minutes, forty seconds (± about 7 seconds) commences, a period determined by resistors R8, R9, R10 and polystyrene close tolerance capacitor C2. Substituted components cannot be used in place of C2, as this would significantly affect accuracy.

Capacitor C1 in series with resistor R7 applies a power-on reset to IC2, so that it begins operation in a predictable state when timing commences. Resistor R6 discharges C1 when the device is switched off.

Light Work

The l.e.d. D2 is illuminated upon power-up via current limiting resistor R11, as pin 7 of IC2 at this point is at logic 0. Once the timer has been activated, pin 7 begins to oscillate between logic 0 and 1 at a low frequency of 1Hz to 2Hz, resulting in D2 flashing instead.

After four minutes and forty seconds, pin 3 of IC2 switches from logic 0 to 1 and turns on transistor TR1 via current limiting resistor R12, which activates the buzzer WD1. As TR2 is constantly pulsed by pin 5 at approximately 2Hz, the buzzer is given a more noticeable "beep, beep . . ." sound, rather than a constant tone. Capacitors C3 to C5 are noise decoupling components that help stabilize the power supply.

Transistors TR3 and TR4 and resistor R14 form a water-activated switch that automatically applies power to the circuit when the sensor prods are immersed in the water; these are located on a probe containing the thermistor. The circuit should be housed in a metal box and clipped onto the end of the pan handle so that heat and steam cannot come into contact with the components.

It should be noted that once the alarm has sounded, the eggs must be cut open immediately, so that they cannot continue to cook from the heat retained in them.

M. A. Jones, Harrogate, N. Yorkshire

Heart Rate Monitor – See The Beat

THE simple but very reliable monitor shown in Fig.2 will be an asset to those who have difficulty finding their pulse in their wrist. It is also useful for checking the pulse rate immediately after exercise, which should be well above the normal rate of 60-80 beats per minute if any benefit from the exercise is to be derived.

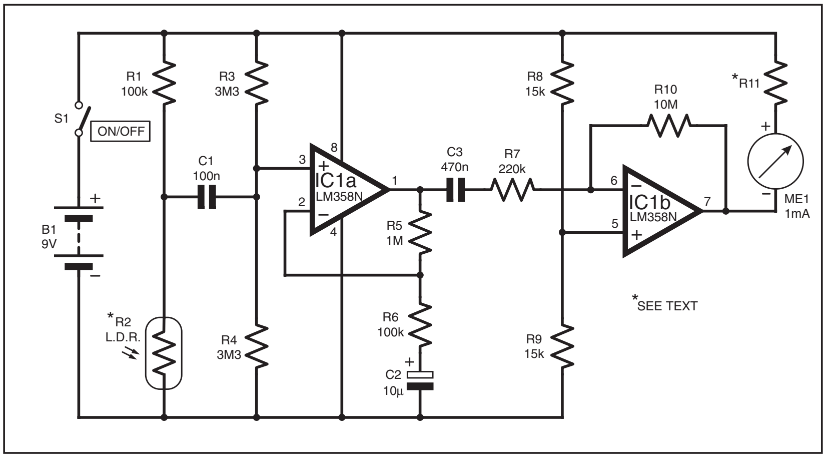


Fig.2. Heart Rate Monitor circuit diagram.

Light Finger

The device depends for its operation on variations in light intensity. When a finger is placed on a light dependent resistor R2, the l.d.r. detects the minute changes in light level caused by variations in blood flow as the heart pumps. These light changes are translated into minute voltage fluctuations that are subsequently amplified through a two-stage amplifier, a non-inverting op.amp (IC1a) and an inverting op.amp (IClb), by a gain of approximately 800 as determined by resistors R5, R7 and R10.

At the output (pin 7 of IC1b), each heartbeat is reflected in the rhythmical swing of a meter needle across the dial of a milliammeter (ME1) or other suitable panel meter. No special lighting is needed as the l.d.r. is able to "see" through a finger tip in normal daylight.

The gain of the first op.amp is fed into the second and the overall gain is sufficient to obtain a healthy swing of the meter needle. Almost any moving coil meter can be pressed into service because we are not concerned with voltage or current measurement, only the needle deflections across the dial. However, be sure to fit a series limiting resistor R11 to suit the meter and prevent damage.

A miniature button-type l.d.r. is preferred to the bulkier ORP12 so that the finger can completely cover the sensor surface and prevent stray lighting from reaching it. Two discrete 741 op.amps could be used in place of the LM358N if more readily available.

Although not shown here, the prototype also housed a 30-second timer, using a 555 with an l.e.d. indicator. When the timer is initiated, the needle movements are counted during the 30 second period, then doubled to obtain pulses per minute. The circuit could also be adapted as a front-end to more advanced monitoring systems.

In use, after the unit is switched on, allow several seconds for the meter needle to stabilise somewhere about mid-scale. Place the fleshy part of the middle finger tip on the l.d.r. and rest the hand comfortably while keeping it still, then monitor the meter needle movement. If the meter needle responds by only a small amount, it is probably because your hand is excessively cold and the circulation is sluggish.

Tony Lee,
Old Reynella, Australia

Microwatt L.E.D. Flasher – Relaxing Light

THE circuit of Fig.3 is a complementary relaxation oscillator that has been utilised to form a low power l.e.d. flasher. The heart of the circuit is the 5·1V 0·5W Zener diode D2, the absence of which reduces the operating efficiency of the circuit. Current from the anode of the Zener diode provides base bias for transistor TR2.

In order to reduce the current requirement of TR2 to a minimum, a high gain *npn* transistor (BC549C) has been selected. The resistor R1 is the energy saver which acts in conjunction with capacitor C1, a reservoir for the whole circuit. Transistor TR1 (BC559) is a *pnp* type that provides current for the flash.

To get a flash of fairly good intensity C1 has to be kept fully charged and the action is obtained by keeping the time constant of R1/ C1 smaller than the time constant of the timing circuit around TR2, which consists of components R3 to R5 and C2. The capacitors should ideally be low leakage tantalum types.

Using component values as per the circuit diagram, the flash rate obtained was approximately 40 per minute with fairly good intensity using a 9V battery. The actual current consumption at the precise time of flash is well below 0·4mA. The circuit is tolerant of voltages ranging from 6V to 12V though a frequency variation is noticeable when supply voltage varies.

Unlike many other flasher circuits, this one has a very short flash duration. The instantaneous release of energy from the 100μF capacitor (C1) has to be fully utilised to illuminate the l.e.d., and a 3mm clear red l.e.d. was chosen as a satisfactory compromise.

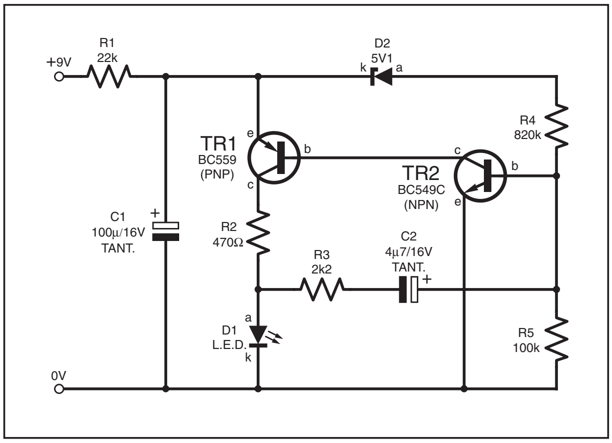


Fig.3. Circuit diagram for a Microwatt L.E.D. Flasher.

Experimenters might find various other applications due to the very economical power consumption, e.g. by replacing Rl with a 2k2 resistor and addition of a small piezo buzzer in place of the l.e.d. or in parallel with it, thus converting it into a low current bleeper.

K.N.S. Nair,
Selangor, Malaysia.

Signing Off . . .

Sadly this is the last *Ingenuity Unlimited* column that I will be hosting, but don't worry, *IU* will continue. It has been my pleasure to help bring you almost 300 readers' circuits since the original *Practical Electronics* column was relaunched in *EPE* nearly ten years ago. Unfortunately, pressure of work has gained the upper hand, and so I will be handing over to the Editorial staff at *EPE* HQ who will continue to publish a selection of your circuit ideas with valuable prizes donated by Pico Technology for the best.

I'll still be working hard as usual over at *Circuit Surgery* and *Net Work* – the Internet column, and working on a number of other projects as well. I would like to express my gratitude to all those readers, correspondents and friends around the world who have sent their good wishes and offered me their encouragement over the years. It is much appreciated, and it has been great fun. *Alan Winstanley.*

Constructional Project

DOOR CHIME

BART TREPAK

Add a touch of nostalgia to your front door and have a real "ding-a-ling" with this low-cost unit.

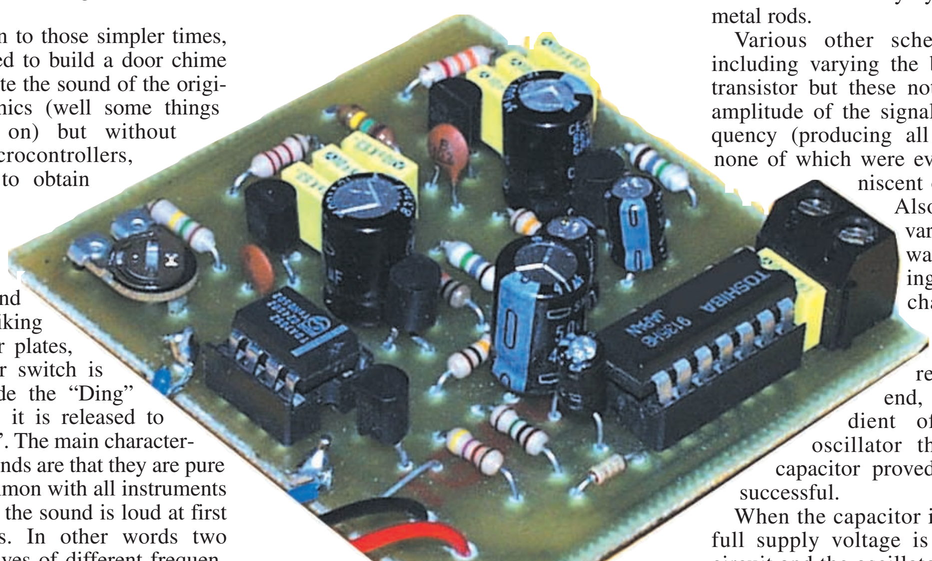
IN the good old days, when computers were huge monsters that lived on the air conditioned top floors of banks and insurance company headquarters and PICs were used with shovels on building sites to dig holes, life was so much simpler.

Nobody in their right mind would want to use either of these to announce the arrival of a visitor to their door and instead a far simpler solution was found – the door chime, which had the added advantage of not playing the Wedding March for twenty minutes each time a double glazing salesman came to call.

Luckily, these did not exist either and only the familiar "ding-dong" sound of the lady selling cosmetics disturbed the peace and tranquillity of the family as they huddled around their warm valve wireless set listening to the Home Service instead of arguing about which of the hundred and fifty odd channels to watch or record on their top of the range digital satellite TV/DVD recorder . . . Ah, those were the days . . . now even nostalgia isn't what it used to be!

To try to return to those simpler times, the author decided to build a door chime that would recreate the sound of the original with electronics (well some things have to move on) but without recourse to microcontrollers, ROMs or hard to obtain special i.c.s.

Mechanical door chimes produced their characteristic sound by alternately striking two steel rods or plates, once as the door switch is pushed to provide the "Ding" and the other as it is released to sound the "Dong". The main characteristics of these sounds are that they are pure tones and, in common with all instruments which are struck, the sound is loud at first and then decays. In other words two decaying sine waves of different frequencies must be generated, one when the switch is pressed and one when it is released.



SINE WAVE OSCILLATORS

At first glance this seems simple enough to do and there are many circuits for producing sine waves. Basically, an inverting amplifier with its output connected to a feedback network which at a certain frequency produces a phase change of 180 degrees is all that is required.

When this is coupled to the input of the amplifier which itself exhibits a 180 degree phase change between its input and output, the total phase change becomes 360 degrees (i.e. in phase). This means that the circuit will oscillate but only if the gain is high enough to replace the inevitable losses in the feedback circuit.

If the gain is too high, the amplitude of the output waveform will grow until it limits or clips on the supply rails producing distortion or a square wave (which does not sound so pleasing). If it is too low the circuit may not start to oscillate at all. Many sine wave oscillators therefore employ some form of circuit to control the gain of the amplifier and keep it stable.

PHASE SHIFT

The circuit chosen was a phase shift oscillator where the feedback is provided by a three-stage high-pass network with each stage providing a phase shift of 60 degrees. Here oscillation occurs at the frequency at which the phase shift through the network is 180 degrees and this depends on the values of the capacitors and resistors used.

Normally they will have the same value, although making one of the resistors variable allows the frequency to be adjusted within limits. The frequency of oscillation is given by the formula: $f = 1/2\sqrt{(6RC)}$. The gain required to sustain oscillation is easily supplied by a simple transistor amplifier.

DELAYED RESPONSE

To produce a decaying output rather than one which persists for as long as the battery is connected appeared much more difficult. Some form of voltage controlled amplifier or attenuator was considered but this was rejected as being too complicated – we are after all only trying to replace two metal rods.

Various other schemes were tried including varying the base drive to the transistor but these not only varied the amplitude of the signal but also its frequency (producing all sorts of sounds none of which were even vaguely reminiscent of a door chime). Also, the amplitude varied in the wrong way hardly changing at first and then changing rapidly rather than smoothly as required. In the end, the simple expedient of powering the oscillator through a (large) capacitor proved to be the most successful.

When the capacitor is discharged, the full supply voltage is available to the circuit and the oscillator produces a signal with an amplitude of several volts. As the capacitor charges up via the oscillator circuit, less and less of the

supply voltage is available across the oscillator itself and so its amplitude falls until eventually the signal becomes inaudible.

The circuit continues to oscillate without clipping or suddenly cutting out at a certain minimum voltage level thus producing a smoothly reducing signal. It also has the great advantage in a door chime circuit, which spends most of its time in the stand-by state, in reducing the current drain to zero once the capacitor is fully charged. In this state it draws no current and is ready for the next caller requiring only the capacitor to be discharged to initiate another cycle.

A SWITCH IN TIME

Since two tones must be generated, two oscillators are required together with their associated capacitors. In theory, the capacitor could be discharged by the door switch but since the two tones do not sound simultaneously, the capacitors need to be discharged sequentially – the first when the switch is closed and the second when it opens. As well as this, both contacts would have to remain open during the stand-by condition so that neither capacitor was shorted out and this would require some pretty fancy switching.

Nowadays, of course, you can have any type of doorbell switch you like on your door – as long as it is a simple push-to-make type. Double-pole or changeover types suitable for mounting on your front door are not readily available (if at all) and you would probably not want to change your existing one anyway so that a further circuit must be added to switch on the oscillators in the correct sequence under the control of a single contact.

CIRCUIT DETAILS

The full circuit diagram of the Door Chime is shown in Fig.1 and consists of two oscillators built around TR1 and TR3, the circuitry for switching them on and an audio amplifier, IC2, to drive the speaker.

The switching stage is centred on IC1, a quad CMOS NAND gate and all of the gates are connected as logic inverters. When the doorbell switch S1 is pressed, the input of the first inverter, IC1a, goes high causing its output to go low and the output of the second inverter, IC1b, to go high.

Both of these inverters drive *pnp* transistors, TR2 and TR4, via capacitors C5 and C10, so that when the output of an inverter goes low, the associated transistor is switched on, briefly discharging its output capacitor (C6/C11 as appropriate) and switching on its oscillator. When the output of the inverter goes high however, it has no effect on the transistor which remains off.

Thus when the door switch is pressed, TR2 turns on briefly and when it is released, TR4 is turned on so that the two oscillators are switched on sequentially. Note that if the switch is held depressed, then only the first (Ding) oscillator TR1 is switched on and the second (or Dong) oscillator TR3 will only sound when the switch is released.

SWITCH-OFF

The two oscillators switch off automatically by themselves (when the voltage on the negative plates of capacitors C6 and C11 falls) but the audio amplifier, IC2, must also be switched off in order to reduce the current drain of the circuit. This is done by wiring the remaining two gates, IC1c and IC1d, as a monostable.

When the input of IC1c goes low (which happens when the switch is pressed) its output will go high and capacitor C14 will charge quickly via diode Dl. This will cause the output of IC1d to go low switching on transistor TR5 and the supply to the audio amplifier IC2. Note that the transistor will remain on for as long as the door switch is held pressed.

When the switch is released, C14 discharges via resistor R15 until eventually the gate output goes low, switching off the transistor and the supply to the amplifier. The values of C14 and R15 are chosen to ensure that this will happen only after the second oscillator has ceased to function.

AUDIO AMPLIFIER

The audio amplifier (IC2) chosen is the TDA7052 power amp i.c. which, in fact, contains two amplifiers which drive loudspeaker LS1 in a bridge configuration. This gives an output which is typically four times greater than that which could be achieved with a single-ended output and ensures a loud signal even with a relatively low supply voltage.

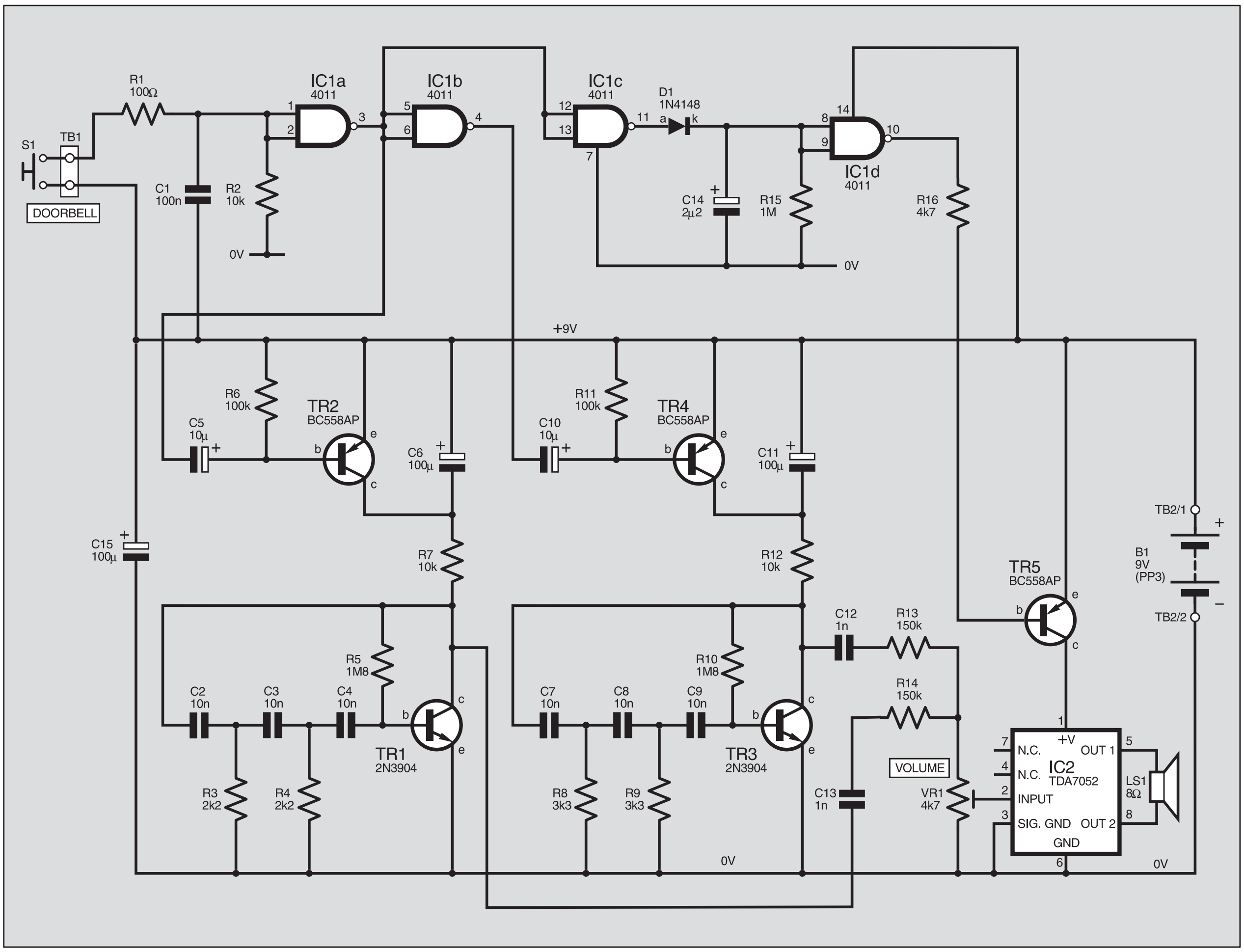


Fig.1. Complete circuit diagram for the Door Chime. S1 is the doorbell pushswitch.

As there is no d.c. voltage across the loudspeaker in amplifiers using this configuration, the usual large value coupling capacitor is not required. Apart from a supply decoupling capacitor (C15), the only other component needed is a Volume control which in this case is preset type (VR1).

The outputs of the oscillators are fed to the amplifier input (IC2 pin 2) via capacitors C12 and C13 and resistors R13 and R14 which attenuate and mix the two oscillator outputs across level-setting preset VR1.

As mentioned, to reduce the current drain, the supply to the amplifier is also switched off when the chimes stop. The absence of a speaker coupling capacitor is therefore an advantage as there are no audible clicks when the supply is switched on and off.

The circuit is powered by a 9 volt battery and the current drain in stand-by, which with this sort of application is most of the time, is virtually zero so that battery life will be close to the shelf life.

CONSTRUCTION

Initially it was intended to build the circuit on stripboard but as the number of components grew it was decided to design a printed circuit board. This will simplify construction quite considerably.

The final component layout, full-size copper foil master and wiring details are shown in Fig.2. This board is available from the *EPE PCB Service*, code 390.

All of the components except for the loudspeaker and battery (and, of course, the doorbell switch) are mounted on the board and these are connected to the p.c.b. via flying leads, either soldered directly to the board or through terminal blocks. The components are all pretty standard and no special precautions need be taken other than to make sure all electrolytic capacitors, transistors and other polarity sensitive components are mounted the correct way around.

Note also that transistors TR1 and TR3 are *npn* types while TR2, TR4 and TR5 are *pnp*. The pinouts of the *npn* types specified are slightly unusual and so if you intend to use substitute devices, such as BC548 or BC182, you will need to check their pinouts first. Being a CMOS device, IC2 should be handled with care and mounted in a 14-pin socket. Although IC1 is not sensitive to static, a socket was also used for this device.

The circuit is powered by a 9V PP3 battery and although the layout shows a terminal block, TB2, to connect this, a simple PP3 battery connector and its leads may be used and soldered directly in its place. Note that there is also a wire link adjacent to this terminal block which can be made from a discarded component lead.

The loudspeaker LS1 can be a miniature one and this should be soldered to the board at the position shown using flying leads. It is a good idea to use solder pins here (and for the battery connector if a terminal block is not used) to avoid damaging the p.c.b. tracks as wires soldered directly to the board often break at this point leading to repeated soldering operations.

TESTING

Provided the circuit layout has been carefully followed, the unit should work as soon as a speaker and battery are connected. The Volume control preset VR1 should be adjusted to give a pleasing sound without distortion which can occur at high volumes if the output of the amplifier clips on the supply rails.

Although the component values given should produce an acceptable door chime sound, this can be modified according to personal taste. As mentioned, the basic oscillator frequencies can be altered by varying one of the resistors in the ladder network.

COMPONENTS

Resistors

R1	100Ω
R2, R7, R12	10k (3 off)
R3, R4	2k2 (2 off)
R5, R10	1M8 (2 off)
R6, R11	100k (2 off)
R8, R9	3k3 (2 off)
R13, R14	150k (2 off)
R15	1M
R16	4k7

All 0·25W 5% carbon film

See SHOP TALK page

Potentiometer

VR1	4k7 carbon preset, horizontal

Capacitors

C1	100n polyester
C2 to C4, C7 to C9	10n polyester (6 off)
C5, C10	10µ radial elect. 16V (2 off)
C6, C11, C15	100µ radial elect. 16V (3 off)
C12, C13	1n disc ceramic (2 off)
C14	2µ2 radial elect. 16V

Semiconductors

D1	1N4148 signal diode
TR1, TR3	2N3904 *npn* low power transistor (2 off)
TR2, TR4, TR5	BC558 *pnp* low power transistor (3 off)
IC1	4011 CMOS quad 2-input NAND gate
IC2	TDA7052 power amp.

Miscellaneous

LS1	8 ohm miniature loudspeaker
B1	9V battery (PP3), with clips and leads
TB1, TB2	2-way, p.c.b. mounting, screw terminal block (2 off)

Printed circuit board available from the *EPE PCB Service*, code 390; plastic case, size and type to choice; doorbell switch, push-to-make (see text); 8-pin d.i.l. socket; 14-pin d.i.l. socket; connecting wire; solder pins; solder etc.

Approx. Cost Guidance Only **£12** *excl. batts & speaker*

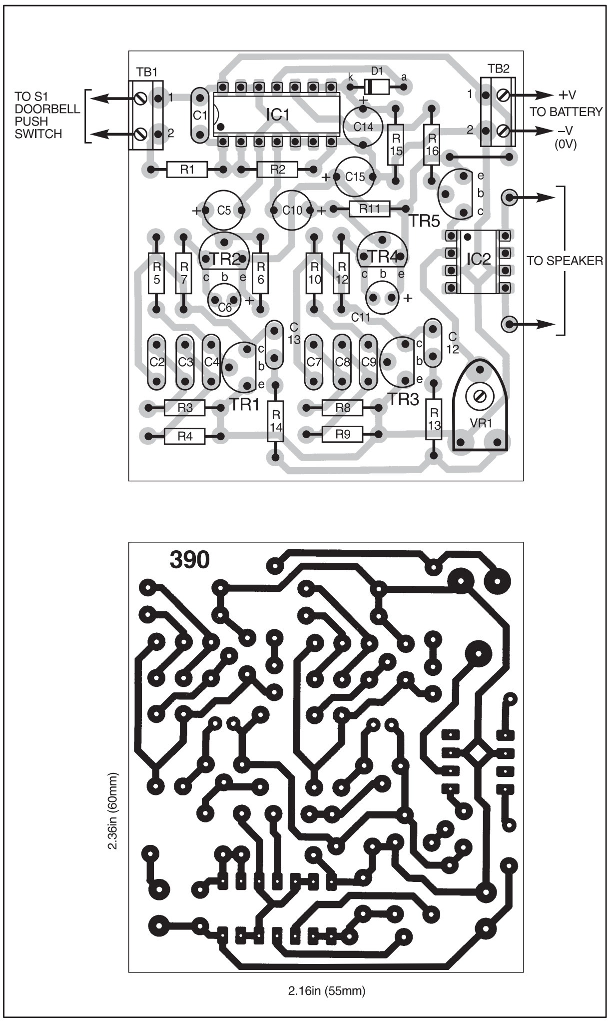


Fig.2. Printed circuit board component layout, wiring details and full-size copper foil master for the Door Chime.

This is perhaps done most easily by substituting a preset potentiometer in place of the resistors R4 and/or R9 and adjusting it to get the desired effect. Note that as well as altering the frequency, it will also change the amplitude of the note which can cause distortion of the wave shape by over driving the output amplifier but this can usually be corrected by adjusting the volume control preset.

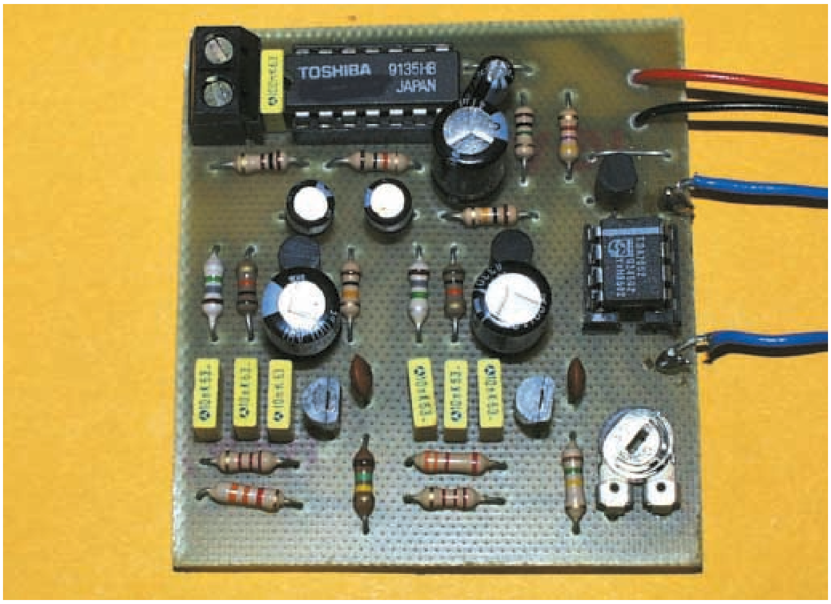
It can also produce less than pleasing results especially when mixed with the output of the other oscillator. If a radically different frequency is required, it is probably better to change the values of the capacitors.

DECAY TIME

The other characteristic which can be altered is the decay time and this is controlled by the current drain of the oscillator transistors (which is probably best left as it is) and the values of the series capacitors C6 and C11. These may be increased to 470μF or beyond or indeed decreased depending on taste, although both should have the same value to preserve the "ding-dong" effect.

In this case, the value of C14 would also need to be increased to ensure that the amplifier remains powered until the tone has died away. The values of C5 and C10 may also need to be increased to ensure that the capacitors are fully discharged at the start of each tone.

If the first tone is still sounding loudly when the second one commences, the two frequencies will beat together resulting in harmonics being generated and this can lead to the production of some more or less pleasant (or interesting) sounds.



Unlike custom i.c.s where the timing and the frequencies generated are all derived from one master clock oscillator, here each note can be adjusted to produce any sound of any duration required. By swapping the values of R4 and R9 for example, a "dong-ding" effect can be produced.

There is also no reason why a further oscillator could not be added to provide a 3-note chime or indeed a larger number to recreate the Westminster chimes. Although, in these cases the oscillator switching signals would need to be derived from a counter such as the CMOS 4017 with the pushswitch providing only the start signal.

While these modifications may be suitable as a door chime to produce just the sound you were looking for, they will do little to recreate those "good old days"!

New Technology Update

Antennae with a high dielectric constant are less prone to proximity effects in mobile phones. Ian Poole reports.

MENTION an antenna to anyone and it conjures up an image of either a television Yagi antenna array on the chimneystack of a house, or a view of an amateur radio wire antenna.

In recent years it has been possible to implement far better antenna designs as a result of a vast array of simulation software that is available. It is possible to predict performance in terms of gain, direction pattern and many other parameters before any metal is put together.

These simulations can also take account of nearby objects that may affect the performance. As a result, major improvements have been made in the way antennas are designed, enabling far more efficient designs to be made more quickly. The need to perform many long tests on an antenna test site has been vastly reduced as the designs can be made almost perfectly first time.

A considerable amount of work has been put into the development methods for conventional conducting antennas. However, there has been plenty of development directed towards new ideas for antennas. With the increasing requirements for wireless links, antennas need to be made smaller, and to be incorporated into equipment more easily.

Proximity Effects

One of the major restrictions with antennas that use existing techniques is that nearby objects have a considerable effect on the performance. This means that for antennas such as those used in mobile phones, the proximity of other parts of the phone need to be taken into consideration. Naturally hand and body capacitance from the user has a major effect on the antenna and this will vary quite considerably dependent upon a number of factors, including the way the user is holding the phone, the electrical characteristics of his or her body and so forth.

Antennas on mobile phones themselves may only be 45% efficient under ideal conditions. However when the phone is held close to the head this can drop to as low as just a few percent. This means that the transmitter section of the phone needs to generate more power to enable reliable communication to be maintained with the base station, and this results in a much greater level of drain on the battery.

High Dielectric Antennae

To address these problems a Cambridge (UK) based company named Antenova has developed a new type of antenna called a high dielectric antenna (HDA). This type of antenna uses material with a high dielectric constant as the basis of the radiating element rather than a conducting element as used in a conventional antenna.

The idea has been known about for many years. The first ideas were postulated in the 1930s. However, it has not been possible to develop them until recently. The electric and magnetic fields are contained within the dielectric and as a result it was not possible to measure them. Some early experimental models were built to demonstrate the principal in the laboratory, but their bandwidth was small, and they were not repeatable because of a lack of understanding of the electric and magnetic modes being excited within the dielectric.

During the 1990s development of simulation software took place and as a result it was possible to gain a much clearer picture of what was happening within the dielectric. It became possible to plot the electric and magnetic fields and from this an understanding of the modes in which the dielectric was being excited could be gained.

Physical Aspects

The antennas may be constructed using a small cylinder of dielectric material with a disc attached. A small metal or conducting probe is inserted into the material to act as a launcher and this is fed with the RF signal. If the relationship between the radio frequency signal and the dimensions of the dielectric are correct then a displacement current standing wave pattern will be set up. Using Maxwell's equations it has been predicted that this will radiate, and this indeed is what actually happens.

These dielectric antennas are physically smaller than their conducting counterparts. Under some circumstances they may be only a tenth the size and this can be a distinct advantage. Many of today's wireless devices are small, requiring low profile antennas and the new HDAs are ideal candidates for these applications because they can be accommodated more easily within the electronics.

A further advantage is that they are less affected by nearby objects and this too enables them to be incorporated more easily onto a circuit card or other item. The fields are almost totally contained within the dielectric of the antenna itself, whereas the fields from a conventional antenna extend out by a wavelength and more, with the result that any objects within this range have a major effect on performance.

As a result of the relative immunity to nearby objects it is possible to have an HDA design where two separate antennas are placed very close to one another without any noticeable effect on performance.

Bluetooth

The new technology is ideal for many of the emerging wireless communications systems. Bluetooth, WiFi, and the like, all need small antennas that can be incorporated into a small electronics card. They also lend themselves well to many cellular telecomms applications, although the technology is better suited to frequencies above around 900MHz.

Whilst they can be used for bands within the 850MHz to 900MHz region, the higher frequency bands around 1800MHz and 1900MHz are far more applicable, along with many of the new 3G allocations that are slightly higher in frequency.

Antenova have built relationships with cellphone manufacturers and it is expected the new technology will be used extensively in this arena before long.

Currently much of the development work that is under way is focussed on frequencies around 5·8GHz. This is one of the so-called "unlicensed" bands that are starting to be used by some of the wireless LAN cards.

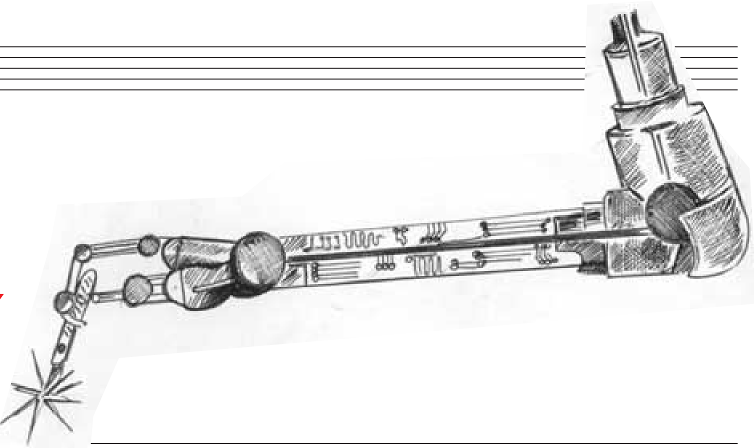
At the moment the 2·4GHz band is the most popular, but with the rapidly growing requirement for even faster data rates, people are migrating to 5·8GHz where the levels of interference are less and the bandwidth is greater, both elements enabling higher data rates to be achieved.

Diversity Reception

The fact that two antennas can operate close to one another provides the opportunity to provide what is called diversity reception. This form of reception is required because signals often reach a receiver via several paths. When they combine at the receiving antenna they may combine constructively to provide a better signal or they may tend to cancel one another out.

The interference patterns set up by the signals arriving via several paths mean that even a relatively short change in distance can make a large difference to the signal. As a result, the problem can be overcome by having two separate receiver front ends and two antennas relatively close to one another. The best signal is then used by the overall receiver system. As the HDAs can be operated close to one another they are ideal for using for diversity reception systems.

Further information can be gained from the Antenova website at **www.antenova.com** and more information about new technology can be found at **www.radio-electronics.com**.



CIRCUIT SURGERY

ALAN WINSTANLEY and IAN BELL

This month, we unravel a subtle timing problem on a reader's digital circuit. We also offer more circuit diagram tips for beginners, illustrated with a selection of schematic symbols of common components.

Perfect Timing

Dr. G. L. Manning of Edgware wrote to describe his interesting experiences of timing problems with digital counters, about which we can make some enlightening observations. Some excerpts of his letter follow:

In the circuit shown in Fig.1 (which is part of a larger circuit), the required count length is from 0 through to 5 (0101 binary). The various binary values are decoded to an active low 1-of-n code by IC4. The NAND gate detects the 6 condition and resets the counter by a low signal applied to $\overline{CLR}$.

The small time the counter spends in the 6 state is not a problem in this application, however, it is this resetting that goes wrong. It worked as required on a breadboard with its stray capacitance but only worked on a p.c.b. once an extra delaying capacitance was added in the form of C14.

On my unmodified p.c.b. version the count sequence was 0 1 2 3 0... (binary 0000 0001 0010 0011 0000). I suspect that the synchronous flip-flops in IC2 take slightly different times to settle, so after 0011 the next output could be 0111 for just long enough to trigger a reset, prior to settling at the steady state of 0100. Hence, the capacitor C14 slows down the transition of the bit C so that the intermediate combination does not occur.

Further investigation involved replacing IC2 with a ripple (asynchronous) counter which has the advantage that bit C is not clocked (low-to-high transition) until preceding bit B settles to zero (its high-to-low transition). Perfect function is observed without the need for C14.

Finally Dr. Manning adds a couple of questions:

Directly clearing the synchronous counter directly from output Y6 (omitting IC3A and C14) also works correctly. Is there some subtle timing/propagation delay in IC4 which means that it does not respond to the intermediate output value?

A final observation is that all chips tested behaved the same, but all were from the same manufacturer. Are such critical timing errors manufacturer-dependent? Thanks from ***Godfrey Manning, G4GLM***

Let's deal with the questions first. The response of digital circuits to (relatively) short duration pulses (glitches) is rather like the inertia of objects when they are pushed. Objects may or may not move when given a (relatively) gentle push (due to friction), and logic circuits may or may not respond when a glitch is applied to one of their inputs.

The "inertia" is different for different circuits, so it is quite natural to find that the NAND gate responds to the short duration intermediate state from the counter, whereas the decoder does not. This behaviour can be described as a subtle timing issue, but it is not an error. There is, however, another possible explanation for this behaviour, which we discuss later.

The response to glitches does not just vary between different circuit "designs" (e.g. NAND gate and decoder); it also varies between individual instances of circuits or gates (e.g. two individual decoder chips). Manufacturer's datasheets usually specify the typical delay and longest delay for the response of the logic chip. If a chip is *slower* than the *longest* delay specified, then it has not met the specification and you may have a right to replacement; however, there is usually no *minimum* delay specified so a particularly fast device is not usually regarded as being out of specification.

Therefore, two manufacturers could produce nominally the same i.c. type (74LS161 or whatever) and one manufacturer's devices could well be on average much faster than an other. Thus it is possible to find circuits that will work (at least most of the time) with one manufacturer's chips and fail (at least most of the time) with another's. In practice this is pretty rare, but it does happen.

The Chips Are Down

We know of cases where production lines have been halted due to almost 100 per cent failures of a circuit board after a change of chip manufacturer for a basic logic device, or after the chip manufacturer changed their production process and suddenly an i.c. was (for example) much faster than before. If the "new" chip is in specification then the board manufacturer has no claim against the chip manufacturer.

Such problems occur in circuit designs that are too sensitive to possible variations in circuit parameters (such as gate delay). Asynchronously resetting counters as shown in Fig.1 is an example of this – it is quite common practice, but it does not always work.

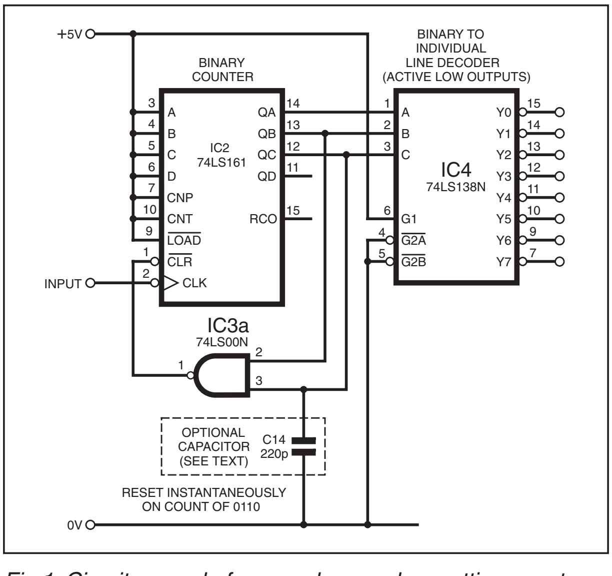


Fig.1. Circuit example for asynchronously resetting counters.

For mass-produced commercial electronic designs it is usually better to avoid such sensitivities, but for hobbyist designs, where typically only one copy of the circuit is made the fact that tweaks such as adding a capacitor can make the circuit work means that it is not so critical. Having said that, it is good practice for the amateur designer to try to avoid having to use tweaks, by designing a more robust circuit in the first place.

There are a few variations on Fig.1 that could help in this respect: one approach is to use a counter that is guaranteed not to produce a reset glitch on the wrong count. The reader's use of the asynchronous counter would appear to be a solution here, but it is a bit ironic as asynchronous counters are often avoided in circuits like this because of their tendency to produce glitches due to intermediate output states. Although it worked in this case it is not a general solution!

Bit of a Problem

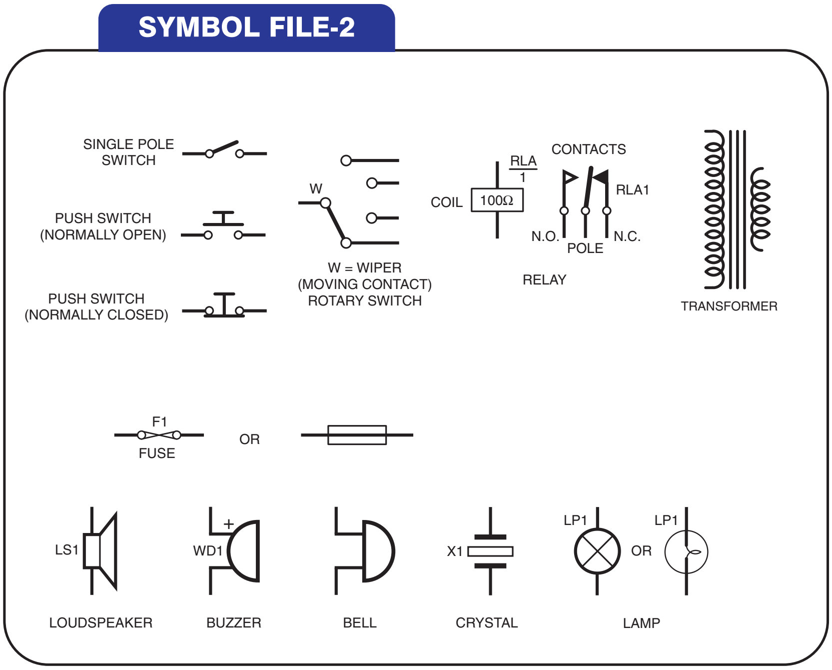
One potential problem with the circuit shown in Fig.1 is that the reset is produced by detecting bits B and C being equal to 1, irrespective of bit A. This allows the circuit to reset on a 0111 intermediate output as hypothesized by Dr. Manning.

If a three-input NAND gate were used to detect 0110, then the 0111 intermediate state would be unlikely to trigger the reset. Of course, the A bit would have to be inverted before connection to the NAND gate.

This may also be why using the Y6 output to reset the counter worked – the Y6 output from IC4 is decoded using all the counter's outputs so fewer intermediate states will decode as Y6. This may account for the variation in the circuit's behaviours using the IC3a and Y6 to drive the reset, rather than their different "inertias" as discussed earlier.

A more robust design is obtained by using a *synchronous* reset rather than the asynchronous one employed in Fig.1. The **74LS163** has such a reset, but is otherwise like the 74LS161. The circuit of Fig.1 could be modified to use a 74LS163 by changing the NAND gate (and inverter) to detect binary 5 (0101). A three input gate is needed, but the capacitor is not required.

When the counter is outputting 5, the $\overline{\text{CLR}}$ line will go low causing the counter to reset to 0000 *on the next clock*. Even better would be to connect Y5 to the 74LS163's $\overline{\text{CLR}}$. This would avoid the need for a NAND gate and inverter. In this circuit the counter would never go into the unused 6 state, even for a short time. *I.M.B.*



A selection of common circuit symbols.

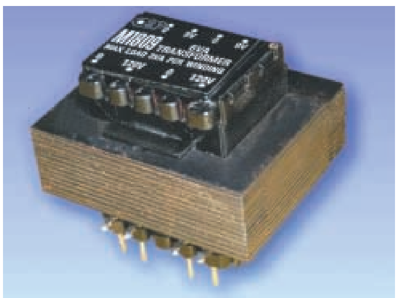
Simple Symbols

In last month's *Circuit Surgery* we described the basic technique of reading a circuit diagram. A circuit schematic is nothing more than a road map, with the towns and cities (electronic components) being interconnected by roads (conductors). We also said that a circuit diagram rarely contains the practical information that may be needed during assembly. Usually we cannot tell from the diagram what type of wire to use nor how to install it: is it handling a sensitive microphone signal or a 3kW heating element?

We must "read" the drawing to find out what is going on, and we must then refer to the constructional information provided. A roadway intersection (electrical junction) is represented by a blob on a circuit diagram – see Fig.1 on page 263 of the April 2003 issue for details. The constructional details will offer essential information that relates to cable specification, insulation and pinout information etc., so that you can ensure that parts are connected together properly and components are inserted the right way round.

In Symbol File-1 last month we showed the symbols for resistors and capacitors, including variations of those used in EPE. This month, more basic schematic information is given Symbol File-2 which shows the symbols that depict basic components including switches, fuses, transformers, buzzers, loudspeakers and more

Rotary Switch, 2-pole 6-way



Mains Transformer, p.c.b. mounting

Relay

Pushswitch

Toggle Switch

Piezo sounder disc

SYMBOL FILE-3

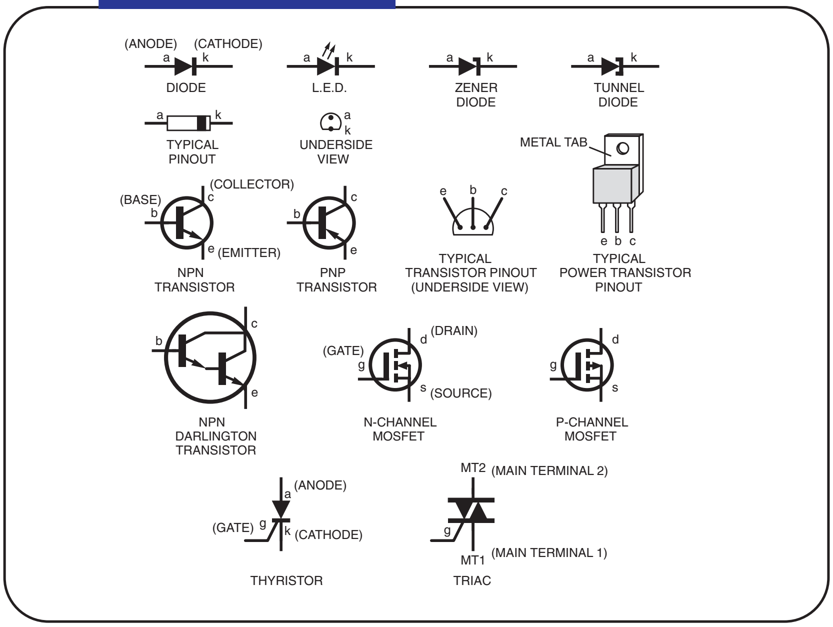


Fig.2. A selection of popular circuit symbols for semiconductors.

besides. With a little practice, you will soon be able to find your way around a circuit diagram and recognise all the major components used by the designer.

A Helping Hand

Devices such as resistors, inductors and capacitors are classed as "passive" components as they have no "electronic intelligence". However, almost every circuit uses "active" semiconductor components including diodes, transistors and integrated circuit chips.

Our experience tells us that the incorrect fitting of semiconductor devices causes a large proportion of circuit construction problems. Almost every semiconductor device requires connecting in a unique way if the circuit is to work successfully, and so in Symbol File-3 we show common semiconductor symbols, which can be compared against their physical pinouts and styles (see photos).

By adding extra information in circuit schematics, *EPE* helps constructors to understand diagrams. Starting with a diode, these have two terminals (anode and cathode), hence the *a* and *k* designations that are shown in our drawings. It is not uncommon to connect these the wrong way round – which may sometimes destroy the device!

Almost always, a stripe on the diode body indicates the cathode (k). (For an example, see the Atmospherics Monitor project last month, and compare the circuit diagram with the stripboard layout). This rule applies to most types of diode, including the Zener voltage reference device also shown.

Light-emitting diodes (l.e.d.s) find their way into many projects and again their terminal arrangement is described in a pinout drawing. Note that in this case the pinout is a worm's eye view of this device, i.e. *as seen looking from underneath the component*. A flat side on the body helps to determine the orientation of the l.e.d. (usually it marks the cathode).

Status Symbols

The symbols for *npn* and *pnp* (hence, "bipolar") transistors, along with a typical specialist "Darlington" transistor (which merely combines two transistors into one package to produce a much higher gain), are also given in Symbol File-3. The use of transistors is often a stumbling block for beginners in electronics, and again *EPE* helps you by labelling the pins *e*, *b*, or *c* for emitter, base or collector respectively in circuit diagrams.

The incorrect connection of transistors is a very common error made by novices, but mistakes can be avoided by comparing the pinout diagrams with the circuit diagram. Smaller low-power bipolar transistors are usually produced in a plastic package whilst power transistors are packaged in TO-3 steel cans or TO-220 plastic tab styles.

In the case of small transistors, pinouts are almost always seen as an **underside** view, but power devices may have a frontal view instead. Either way, identifying the correct polarity of a transistor is essential for successful construction. Fortunately the advent of the Internet means that data sheets can now be downloaded directly from manufacturer's web sites.

On then to MOSFET transistors, and the symbol for the common *n*-channel and *p*-channel devices are given in Symbol File-3. Note how the arrowhead points the other way, when compared with *npn* and *pnp* transistors! As usual, *EPE* designates the terminals (*d*rain, *s*ource and *g*ate) of MOSFETs in circuit diagrams. We described MOSFETs in more detail in the Jan. and Feb. '03 issues of *Circuit Surgery,* and a follow-up is in the pipeline.

Finally, to round off semiconductor circuit symbols, those for a thyristor and triac are shown, along with their terminal designations. It is worth pointing out that triacs are often associated with mains voltage control circuits, and therefore all constructional details must be followed closely, especially concerning the insulation aspects, in order to avoid any possibility of receiving accidental mains electric shock from the triac's metal mounting tab.

In the third part of our circuit diagram mini-series next month, we look at integrated circuits, followed by power rails and ground (earth) symbols and other considerations. *ARW.*

Diode, glass or plastic package

Power Triac, stud mounted

Red L.E.D.

Power Transistors

Transistors, plastic package

Transistors, metal can

EVERYDAY PRACTICAL ELECTRONICS

BACK ISSUES

We can supply back issues of *EPE* by post, most issues from the past three years are available. An *EPE* index for the last five years is also available at **www.epemag.wimborne.co.uk** or see order form below. Alternatively, indexes are published in the December issue for that year. Where we are unable to provide a back issue a photocopy of any *one article* (or *one part* of a series) can be purchased for the same price. Issues from Nov. 98 are available on CD-ROM – see next page – and issues from the last six months are also available to download from **www.epemag.com**.

DID YOU MISS THESE?

JAN '02

PROJECTS ● PIC Magick Musick ● Time Delay Touch Switch ● Versatile Bench Power Supply ● Forever Flasher.
FEATURES ● Teach-In 2002 – Part 3 ● Practically Speaking ● Ingenuity Unlimited ● New Technology Update ● Circuit Surgery ● Net Work – The Internet Page.

FEB '02

PROJECTS ● PIC Spectrum Analyser ● Guitar Practice Amp ● HT Power Supply ● Versatile Current Monitor.
FEATURES ● Teach-In 2002 – Part 4 ● Ingenuity Unlimited ● Russian Space Shuttle Revisited ● Circuit Surgery ● Interface ● New Technology Update ● Net Work – The Internet Page.

MAR '02

PROJECTS ● MK484 Shortwave Radio ● PIC Virus Zapper ● RH Meter ● PIC Mini-Enigma.
FEATURES ● Teach-In 2002 – Part 5 ● Ingenuity Unlimited ● Programming PIC Interrupts–1 ● Circuit Surgery ● Practically Speaking ● New Technology Update ● Net Work – The Internet Page.

APR '02

PROJECTS ● Electric Guitar Tuner ● PIC Controlled Intruder Alarm ● Solar Charge and Go ● Manual Stepper Motor Controller.
FEATURES ● Teach-In 2002 – Part 6 ● Interface ● Programming PIC Interrupts–2 ● Circuit Surgery ● Ingenuity Unlimited ● New Technology Update ● Net Work – The Internet Page ● *FREE* Giant Op.Amp Data Chart.

MAY '02

PROJECTS ● PIC Big-Digit Display ● Simple Audio Circuits – 1 ● Freezer Alarm ● Washing Ready Indicator.
FEATURES ● Teach-In 2002 – Part 7 ● Ingenuity Unlimited ● Practically Speaking ● New Technology Update ● Circuit Surgery ● Net Work – The Internet Page.

JUNE '02

PROJECTS ● Biopic Heartbeat Monitor ● Frequency Standard Generator ● Simple Audio Circuits – 2 ● World Lamp.
FEATURES ● Teach-In 2002 – Part 8 ● Interface ● New Technology Update ● Circuit Surgery ● Ingenuity Unlimited ● Net Work – The Internet Page.

JULY '02

PROJECTS ● EPE StyloPIC ● Infra-Red Autoswitch ● Simple Audio Circuits – 3 ● Rotary Combination Lock.
FEATURES ● Teach-In 2002 – Part 9 ● Practically Speaking ● Using The PIC's PCLATH Command ● Ingenuity Unlimited ● Circuit Surgery ● New Technology Update ● Net Work–The Internet Page.

AUG '02

PROJECTS ● PIC World Clock ● Pickpocket Alarm ● Big-Ears Buggy ● Simple Audio Circuits – 4.
FEATURES ● Teach-In 2002 – Part 10 ● Using Square Roots with PICs ● Ingenuity Unlimited ● Evolutionary Electronics ● Interface ● Circuit Surgery ● Net Work – The Internet Page.

SEPT '02

PROJECTS ● Freebird Glider Control ● Portable Telephone Tester ● *EPE* Morse Code Reader ● Vinyl to CD Preamplifier.
FEATURES ● Circuit Surgery ● New Technology Update ● Practically Speaking ● Net Work ● Flowcode for PICmicro ● Logic Gate Inverter Oscillators ● Net Work – The Internet Page.

OCT '02 Photocopies only

PROJECTS ● *EPE* Bounty Treasure Hunter ● IC Tester ● Headset Communicator ● PIC-Pocket Battleships.
FEATURES ● Circuit Surgery ● New Technology Update ● Logic Gate Inverter Oscillators – 2 ● Interface ● Network – The Internet Page ● Using TK3 With Windows XP and 2000.

NOV '02 Photocopies only

PROJECTS ● *EPE* Hybrid Computer – 1 ● Tuning Fork and Metronome ● Transient Tracker ● PICAXE Projects–1 (Egg Timer – Dice Machine – Quiz Game Monitor).
FEATURES ● Practically Speaking ● Ingenuity Unlimited ● Circuit Surgery ● New Technology Update ● Net Work – The Internet Page.

DEC '02

PROJECTS ● Versatile PIC Flasher ● *EPE* Hybrid Computer – 2 ● Door Defender ● PICAXE Projects – 2 (Temperature Sensor – Voltage Sensor – VU Indicator).
FEATURES ● Electronic Paper ● Alternative Uses for Transistors ● Interface ● Circuit Surgery ● New Technology Update ● Ingenuity Unlimited ● Net Work – The Internet Page ● 2002 Annual Index.

JAN '03

PROJECTS ● *EPE* Minder ● F.M. Frequency Surfer ● Wind Speed Meter ● PICAXE Projects–3 (Chaser Lights).
FEATURES ● Who Really Invented The Transistor ● TechnoTalk ● Circuit Surgery ● Practically Speaking ● New Technology Update ● Computer GOTOs ● Ingenuity Unlimited ● Net Work – The Internet Page.

FEB '03

PROJECTS ● Wind Tunnel ● Brainibot Buggy ● Back To Basics–1 (Hearing Aid, Audio Power Amplifier) ● Tesla High Voltage Transformer.
FEATURES ● In The Bag ● Techno Talk ● Circuit Surgery ● New Technology Update ● Interface ● Ingenuity Unlimited ● Net Work – The Internet Page.

MAR '03

PROJECTS ● Wind-Up Torch Mk II ● 200kHz Function Generator ● Driver Alert ● Back-To-Basics–2 (Metal Detector, Simple Timer).
FEATURES ● Ingenuity Unlimited ● Practically Speaking ● Techno Talk ● New Technology Update ● Circuit Surgery ● Peak LCR Component Analyser Review ● Net Work – The Internet Page.

APR '03

PROJECTS ● Atmospherics Monitor ● Intelligent Garden Lights Controller ● Back-To-Basics–3 (Touch Light, Plant Watering Reminder) ● Earth Resistivity Logger–Part 1.
FEATURES ● Ingenuity Unlimited ● Techno Talk ● New Technology Update ● Circuit Surgery ● Interface ● Network – The Internet Page ● *SPECIAL SUPPLEMENT* – EPE PIC Tutorial V2–Part 1.

BACK ISSUES ONLY £3.50 each inc. UK p&p.
Overseas prices £4 each surface mail, £5.50 each airmail.

We can also supply issues from earlier years: 1998 (**except** Jan. to May, July, Sept., Nov., Dec.), 1999 (**except** Aug., Dec.), 2000 (**except** Feb.), 2001 (**except** May, Sept., Oct.), 2002 (**except** Oct., Nov.) Where we do not have an issue a photocopy of any ***one article*** or ***one part*** of a series can be provided at the same price.

ORDER FORM – BACK ISSUES – PHOTOCOPIES– INDEXES

☐ Send back issues dated . . . .

☐ Send photocopies of (article title and issue date) . . . .

☐ Send copies of last five years indexes (£3.50 for five inc. p&p – Overseas £4 surface, £5.50 airmail)

Name . . . .

Address . . . .

. . . . .Tel: . . . .

☐ I enclose cheque/P.O./bank draft to the value of £ . . . .

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch £ . . . . Switch Issue No. . . . .

Card No. . . . .

Card Expiry Date . . . . Card Security Code . . . . (The last 3 digits on or just under the signature strip)

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk **On-line Shop:** www.epemag.wimborne.co.uk/shopdoor.htm
Payments must be in £ sterling – cheque or bank draft drawn on a UK bank. Normally supplied within seven days of receipt of order.

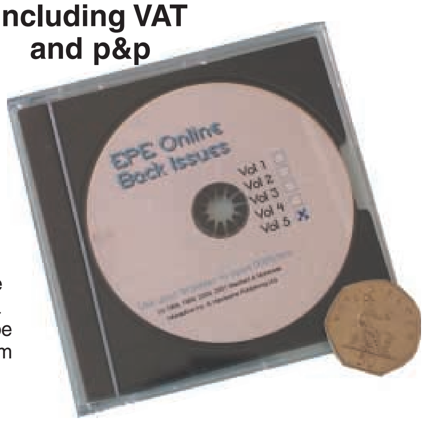
Send a copy of this form, or order by letter if you do not wish to cut your issue.

M05/03

STORE YOUR BACK ISSUES ON MINI CD-ROMS

VOL 7 NOW AVAILABLE

ONLY £14.45 each including VAT and p&p



A great way to buy *EPE* Back Issues – our mini CD-ROMs contain back issues from our *EPE Online* website plus bonus articles, all the relevant PIC software and web links. Note: no free gifts are included. All this for just £14.45 each including postage and packing.

NOTE: These mini CD-ROMs are suitable for use on any PC with a CD-ROM drive. They require Adobe Acrobat Reader (available free from the Internet – **www.adobe.com/acrobat**)

VOL 1 CONTENTS

BACK ISSUES – November 1998 to June 1999 (all the projects, features, news, IUs etc. from all eight issues). Note: No advertisements are included. **PIC PROJECT CODES** – All the available codes for the PIC based projects published in these issues.

VOL 2 CONTENTS

BACK ISSUES – July 1999 to December 1999 (all the projects, features, news, IUs, etc. from all six issues). Note: No advertisements are included. **PIC PROJECT CODES –** All the available codes for the PIC-based projects published in these issues.

VOL 3 CONTENTS

BACK ISSUES – January 2000 to June 2000 (all the projects, features, news, IUs, etc. from all six issues). **PIC PROJECT CODES** – All the available codes for the PIC-based projects published in these issues.

VOL 4 CONTENTS

BACK ISSUES – July 2000 to Dec. 2000 (all the projects, features, news, IUs etc. from all six issues). **PROJECT CODES** – All the available codes for the programmable projects in these issues.

VOL 5 CONTENTS

BACK ISSUES – January 2001 to June 2001 (all the projects, features, news, IUs etc. from all six issues). **PROJECT CODES** – All the available codes for the programmable projects in these issues, including those for *Interface*.

VOL 6 CONTENTS

BACK ISSUES – July 2001 to December 2001 (all the projects, features, news, IUs etc. from all six issues). **PROJECT CODES** – All the available codes for the programmable projects in these issues, including those for *Interface*.

VOL 7 CONTENTS

BACK ISSUES – Jan 2002 to June 2002 (all the projects, features, news, IUs etc. from all six issues). **PROJECT CODES** – All the available codes for the programmable projects in these issues, including those for *Interface*.

EXTRA ARTICLES – ON ALL VOLUMES

BASIC SOLDERING GUIDE – Alan Winstanley's internationally acclaimed fully illustrated guide. **UNDERSTANDING PASSIVE COMPONENTS** – Introduction to the basic principles of passive components. **HOW TO USE INTELLIGENT L.C.Ds**, By Julyan Ilett – An utterly practical guide to interfacing and programming intelligent liquid crystal display modules. **PhyzzyB COMPUTERS BONUS ARTICLE 1** – Signed and Unsigned Binary Numbers. By Clive "Max" Maxfield and Alvin Brown. **PhyzzyB COMPUTERS BONUS ARTICLE 2** – Creating an Event Counter. By Clive "Max" Maxfield and Alvin Brown. **INTERGRAPH COMPUTER SYSTEMS 3D GRAPHICS** – A chapter from Intergraph's book that explains computer graphics technology in an interesting and understandable way with full colour graphics.

EXTRA ARTICLE ON VOL 1 & 2. THE LIFE & WORKS OF KONRAD ZUSE – a brilliant pioneer in the evolution of computers. A bonus article on his life and work written by his eldest son, including many previously unpublished photographs.

Order on-line from

www.epemag.wimborne.co.uk/shopdoor.htm
or www.epemag.com (USA $ prices)
or by phone, Fax, E-mail or Post

BACK ISSUES MINI CD-ROM ORDER FORM

Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 1**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 2**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 3**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 4**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 5**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 6**
Please send me .... (quantity) BACK ISSUES CD-ROM **VOL 7**

Price £14.45 each – includes postage to anywhere in the world.

Name . . . .

Address . . . .

. . . .

. . . . Post Code . . . .

☐ I enclose cheque/P.O./bank draft to the value of £ . . . .

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch

£ . . . .

Card No. . . . .

Card Security Code . . . . (The last 3 digits on or just under the signature strip)

Expiry Date . . . . Switch Issue No. . . . .

SEND TO: **Everyday Practical Electronics, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND.**
Tel: 01202 873872. Fax: 01202 874562.
E-mail: orders@epemag.wimborne.co.uk

Payments must be by card or in £ Sterling – cheque or bank draft drawn on a UK bank.

Normally supplied within seven days of receipt of order.
Send a copy of this form, or order by letter if you do not wish to cut your issue.

READOUT

Email: john.becker@epemag.wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly.

WIN A DIGITAL MULTIMETER

A 3½ digit pocket-sized l.c.d. multimeter which measures a.c. and d.c. voltage, d.c. current and resistance. It can also test diodes and bipolar transistors.

Every month we will give a Digital Multimeter to the author of the best *Readout* letter.

★ LETTER OF THE MONTH ★

P.C.B. CAD AND XP

Dear EPE,

Having read Malc Wiles' letter (*Readout* April '03) of concern about using his present p.c.b. CAD package on new PC equipment has forced me to write to you. Reading his comments about using Windows XP, I assume that, like thousands of other PC users, he has been given misguided information about the operating system.

I, too, have tried many types of p.c.b. CAD program (shareware and commercial), some that were written for DOS, Win95, Win98 and XP. I have not found one yet that will not run on Windows XP. The same applies for most other software too. Over the last 12 months I have converted dozens of Win 98 and Win ME users to XP. The operating system is years ahead of its predecessors, being, in my opinion, the most stable system ever. My system has never crashed nor had blue screens since loading it 14 months ago. XP does not allow the use of badly written programs – the type that attempt to write over critical Windows memory locations.

I have some good advice for those who have been misguided. Don't knock it until you've tried it!

On a change of subject I think your mag is great. Its continuing popularity must be due to the constant variety that is covered in it. My favourite at present is PIC programming.

I am interested to know if you have any plans in the future to build an X, Y, Z plotter that will read Gerber or Drill files produced by p.c.b. CAD programs.

Charles Fenton, via email

You are very reassuring about XP, Charles. I've not tried it for myself yet, still variously using 95, 98 and ME.

Years ago I tried to build a plotter but my limited mechanics skills and equipment defeated me. No-one has ever offered us one that I know of. These days I'm sure that it would actually not be appropriate for us to publish one anyway, with the quality of the printers now available, most readers would probably not find any benefit. Admittedly the size of image that could be handled by a decent plotter would find appeal in some quarters, but few readers are likely to need large p.c.b. images.

Even I do not usually require an image larger than A4, although my PICronos L.E.D. Wall Clock *being published next month is wider than A4, but I adequately coped by combining two printout sections.*

GETTING ORG-ANISED

Dear EPE,

I have recently purchased a *PIC Toolkit MK3* board from Magenta and am working through your *PIC Tutorial*. I have typed the first example listing into my WordPerfect program and saved as an ASCII text file. When I try to assemble from ASM to HEX all I can get is a message telling me that an ORG statement has not been found and that the assembly has been aborted. But I have typed in the ORG statements as needed. What am I doing wrong?

Graham Payne, via email

*I first pointed out to Graham that he need not type it from the published listing as all the software is available for free download from our ftp site, access through the top of our home page at **www.epemag.wimborne.co.uk** (and of course it's also available for purchase on disk as described in the article).*

It would also be a mistake to type in all the example programs since as we progress into the Tutorial, *it is only extracts of the listings that are shown. They are on their own and without all the "fixtures and fittings" that must accompany any PIC program, and so cannot stand alone. However, I told Graham I would be interested to see the file that he had created as I could not understand why it would not assemble even though the required ORGs were there.*

Having received Graham's file the answer was simple! Every typed in statement had been placed hard left of the text page. Consequently TK3 was not finding statements in their correct columns, and overlooking the ORGs in column 1 when it was expecting them in column 2. TK3 and other PIC programming assemblers all expect to find commands starting in column 2. Column 1 is reserved for labels. Just putting a space in front of each line was all that was necessary, making TK3 think the commands were in column 2.

The concept of columns is in a sense somewhat arbitrary. TK3 and many other programmers first examine each line of text and split it into sections. The section splits are initially determined by the position at which blank spaces or tab commands (the "separators") are found, with consecutive occurrences of either being ignored. Any text to the left of the first separator is regarded as being in column 1. Any text between separators one and two is in column 2, etc.

Columns are also created by the presence of commas in some commands, as in the case of MOVF PORTB,W for instance. In this statement MOVF is regarded as in column 2, PORTB in col 3, and W in col 4

When you are keying in PIC commands, ideally make column 2 start so there's room for labels in column 1 and to keep things neat and tabulated. Study my listings.

AMPLIFIERS

Dear EPE,

Have you done any projects about amplifier construction, including the tone controls?

Engr. Daniel A. Offiong, Calabar, Nigeria., via email

We have not done much on amplifiers in recent years, but Raymond Haigh's series of four articles, Simple Audio Circuits, *might interest you, published in May-Aug '02.*

*Back issues can be bought from HQ, see the Back Issues page, or from our Online shop, accessible via the top of our UK home page at **http://www.epemag.wimborne.co.uk**.*

RAIN MAN

Dear EPE,

With regard to Ferren MacIntyre's letter and your comments to him about rain gauges in *Readout* April '03 – for a long time I worked on the telemetry for a river authority and the classic tipping bucket was about the only accurate method of measuring rain fall and also give a close approximation as to the time the rain started/stopped.

The idea of a gauge with no moving parts is very interesting. We actually had a tipping bucket failure due to ants building their nest under it! However, I feel the method outlined by Ferren of using a V notch weir may present a few problems with regard to calibration. From what I can remember of weirs there are a host of calibration curves depending on the amount of flow over the weir.

The manual type of rain gauge uses a funnel to drain the rain into a long small diameter but calibrated glass jar. I wonder if it would be feasible to bring this device up to date by placing a pressure transducer in the jar? The gauge could be interrogated at 15 minute intervals, as is the norm. There is the small problem, though, of when did the rain start? This would have to be done in software which could sense a change in level/stable-level as being the start or stop time respectively.

May I also draw your attention to April's *Plant Watering Reminder*. If the probe is to be left in the soil, which will obviously be moist, then polarisation will occur around the probes with a build up of gas around them and the device will slowly cease to function thereby giving a false indication.

Peter Mitchell, via email

Years ago, Peter, when I designed my first weather centre, I did consider tipping buckets and the like, but decided the mechanics were probably beyond the tools that I have. These days, on behalf of readers who could be in a similar predicament, I still would not wish to go down the mechanical route (one reason I investigated, and have implemented, solid-state wind speed/direction sensing). An ants problem I'd not even considered, but as a programmer I suppose I should have been prepared to eliminate bugs, though!

Certainly I can see a way in which I could design a pressure sensitive rain gauge, but I think the cost could outweigh its usefulness. First the water level sensor would need to be waterproofed. Secondly, I think it would be necessary to also sense atmospheric pressure with another sensor, to remove that influence from the readings of the first sensor. Using ultrasonics, as I commented in my reply to Ferren, is a technique I've used in the past and am again in the design being worked on.

Yes, perhaps a note on polarisation should have been added to the Plant Watering Reminder. *It's worth remembering, though, that it is only a simple circuit and by its nature not equipped with the features that would be expected from a more sophisticated design.*

I discussed the problems of polarisation in brief in Part One of my Earth Resistivity Logger *(April '03). The ER's PC program also has a click button that lets you read about experiments that can be carried out into measuring soil conditions and the associated problems.*

WIND TUNNEL

Dear EPE,

Regarding John Becker's *Wind Tunnel* (Feb '03), and the subject of "smoke", model railway enthusiasts use a 12V device, made in Germany under the Seuthe brand name, which takes a few drops of light oil "down the funnel" to give a modest stream of smoke for several minutes. Another, less messy, source is the humble mozzie-coil (they go for ages) or its perfumed relative, incense/joss-sticks available from "new-age"' shops. Used with a perforated tube across the air-path, several streamers may be made from one source of smoke.

Brian Conner,
Newtown, N.S.W., via email

Thanks, Brian. In fact I tried to get joss-sticks, living in a multi-cultural area, I had expected to find them, but failed. Nor could I get model train smoke from my local model shop.

BIG DIGIT DISPLAY

Dear EPE,

Thanks for the *Big Digit Display* project featured in your May '02 issue. A couple of years ago I "procured" four of these 7-segment displays when Shell service stations in Australia refurbished their outlets. There must have been thousands of these devices that were just trashed. However, no-one was able to supply any control devices or info, apart from your Fig.1 and Fig.2 details. So they've sat in the groundsman's hut at my rugby club gathering dust, spiders and wasps. Yes, I know your article was last year, but it was mid-season over here and too late to start on the project, but now that rugby time is here again I needed to get myself into gear.

Have you had any feedback relating to remote control either by infra-red or r.f.? Could you please advise how I go about finding out that info? It's just that it's a long way to dig a trench to run the cables to the other side of the paddock (and needs much amber nectar to encourage us!).

Peter Finch, Australia, via email

I suggest that you consider using r.f., Peter. It's highly unlikely that infra-red will reach far enough. Browse **www.rfsolutions.co.uk** *for r.f. modules.*

And nectar's even more enjoyable if you don't have to work for it!

PIC PATIENCE

Dear EPE,

I have experienced problems with a PIC16F84 when the power is removed and then quickly turned back on. Nearly all of your circuits use a 100nF capacitor between the power pin and ground which I always include.

The problem is most obvious when an l.c.d. is connected to the chip. I can regularly get the chip to start up with the display showing garbage and nothing else seems to function. Am I doing something wrong? Can you offer an alternative.

Simon Smyth, via email

You should always allow time for a circuit's capacitors to discharge fully following switch off and before re-applying power. Intelligent devices like PICs and l.c.d.s require an initialisation procedure when powering up. By switching off and then on again immediately, the device's internals could be caught in mid-stroke, so to speak, through the disruption of partly losing power, but not enough to be triggered into their initialisation procedure when power resumes. They will certainly get confused if you don't allow time for the power supply voltage to drop sufficiently. So yes, Simon, you are doing something wrong, not being patient!

If what you are trying to do is restart the program from the beginning to observe a particular action, there is an alternative to switching off the power. With all of my PIC designs, there is a diode and resistor between the PIC's MCLR pin (pin 4 on a PIC16F84 and the +5V line). There is then a connection point on the board that joins to pin 4, and usually marked as MCLR. Connect a push-to-make switch between that point and the 0V line. Pressing the switch automatically resets the PIC so that it is forced to restart the program from the beginning when the switch is released.

Do not use this technique with any PIC circuit that has its MCLR pin connected directly to the +5V power rail, i.e. without a buffering resistor such as my circuits have (but other people's designs may not). Doing so would short out the power supply.

SOURCING VB

Dear EPE,

I wish to try my hand at programming in Visual Basic. Is this very hard to master? I am ok with Z80, ST6 and PIC but would like get at the PC. What exactly would I need to purchase to get something up and running? If you can point me in the right direction it would be most helpful.

John Ramsey-Brown, via email

Well, John, I found VB6 much easier to learn than I expected, partly helped by some aspects of it being similar to QBasic which I already knew. Problem now though is that VB6 does not seem to be so obviously available – my local PC World for instance no longer has VB6 on its shelves and has not replaced it with the later and more expensive version, VB Net.

However, talking to their manager recently, I was told that although not on the display shelves, VB6 is shown in their latest catalogue. I found it in the books section on page 557, under Visual Basic. It shows the same version that I learned on and continue to use, Visual Basic 6.0 Deluxe Learning Edition Book/CD package, £75.18. Well worth it.

It is a superb tool and I love using it, as much as I do PICs!

TELE-FEEDING (1)

Dear EPE,

After reading Norman Blair's letter about Tele-Feeding in *Readout* March '03, it occurred to me that I had controlled some equipment via the phone using the Velleman K6501 remote control by telephone. This uses DTFM codes which are fairly secure and up to three outputs are possible from memory. I believe Maplin stock this kit, which might help Norman.

David Larner, via email

Thanks David

TELE-FEEDING (2)

Dear EPE,

There is a way that Norman Blair can use the telephone legally to signal his animal feeder – and with the bonus of having the telephone being usable with an answerphone at the same time. If he purchases/has an answerphone that will either ignore an invalid DTMF code for remote retrieval (or simply doesn't have remote access to begin with), then an acoustically coupled microphone (mic plonked near the answerphone speaker) fed into a cheap DTMF decoder i.c. could do the job well.

He would need to dial in, wait for the outgoing message to finish and then press the required key(s) to activate the gadget. So long as the answering machine had call screening – most do – this would work well, offer a degree of immunity from false activation *and* be completely legal.

If security was not an issue, then he wouldn't even need a PIC, just a DTMF decoder, crystal, a few discretes, an op.amp and a microphone, an output via a general-purpose transistor and a relay with back-EMF diode across its coil. I'm not sure if Maplin still stock DTMF decoders, but Farnell do and they *do* supply to private users at trade price. Come to think of it, up to 12 different devices could be controlled in this way – 16 in fact if Norman has access to a keypad with ABCD as well as the usual set of buttons.

Incidentally, if anyone has a spare i-button hybrid module for sale (sold by Maplin's before they discontinued it), I'd appreciate an email, I cannot find another self-contained device that can recognise up to six i-buttons anywhere.

Mark Tibbert, via email
Mark@lineisp.com

Thank you Mark. So, Norman, you are spoilt for choice thanks to David and Mark. And, readers, can you help Mark?

PICTUT V2 PLUS MSCOMM

Dear EPE,

The April issue is a nice edition – I've been awaiting your *PIC Tutorial V2* with some anticipation as I'm hoping to plug most of the significant gaps in my limited PIC knowledge. From the contents page, it looks like it's going to be great.

Secondly, I read Robert Penfold's April *Interface* article and in the State Monitoring section, he states that there is no way to monitor the RI (Ring Indicator) signal. This isn't entirely correct. The OnComm event is raised with ComEvent set to comEvRing. However, not all chip-sets support this signal. More information can be found in the MSCOMM on-line help.

Joe Farr, via email

Thank you, Joe, we look forward to publishing your sophisticated serial interface that we are discussing with you separately.

STACK ENHANCEMENT

Dear EPE,

In the March issue *Readout*, John Waller writes about the 8-level-deep limit on the stack of PICs such as the F877. Microchip have a software solution for the smaller PICs with only a 2-level stack (application note 527), which could be modified to give a bigger stack on the larger PICs.

David Tilch,
Johannesburg, South Africa, via email

Thanks David. In fact a fair bit of correspondence was generated on this subject, but too lengthy and in-depth to publish. Some of the solutions offered though had such an overhead cost in terms of code involved, I became determined that I would find ways round ever needing to use a stack quantity greater than that allowed by the PICs I currently use.

BROWSE THESE

Dear EPE,

Readers could find the following free software on the web to be interesting:

SIMetrix: **www.newburytech.co.uk**.

Quickfield: **www.tera-analysis.com** or **www.quickfield.com**.

The first is SIMetrix' simulation demo. I have the full copy at work, but the free version (which is sort of node limited) has proved quite useful at home. It allows you to save circuits but there is a limit to how many components can be used in the simulation. I've also used it for producing circuit diagrams (bigger than it will allow you to simulate) which is also useful.

The other one is Quickfield's Student edition. It's a finite element analysis package. I've used it for calculating the resistance of odd shapes of polysilicon on ASICs. You can define a geometry and having defined the resistivity, you can see the current distribution – in living colour. You can then get it to calculate resistance. It also does electrostatic and magnetic stuff. That's probably not what most of your readers do, but it can be really educational.

Just got into your *Toolkit TK3*. Very nice. (Is John on the Microchip payroll? I think they owe him!)

Graham Johnston, via email

Thanks for the info and kind comments Graham – I'm waiting for a huge *cheque from Microchip (even a little one would do), but it's still not come even after these many years of supporting* them! *Ah well, I suppose some things one does for love, not money!*

BACK TO BASICS

BART TREPAK

Part Four

Illustrating how useful circuits can be designed simply using transistors.

LIVE WIRE DETECTOR

When it comes to useful circuits using very few components, this one takes some beating, as a quick look at the component list will show. Using only three transistors, together with one resistor and a light emitting diode (l.e.d.), it performs a whole series of functions that make it useful for professional electricians and DIY enthusiasts alike.

Despite its extreme simplicity, it can be used to detect if a cable is live, identify the live conductor itself, and to test the fuse in a plug without even dismantling it. It can even be used to locate breaks in a circuit, which makes it ideal, for instance, for finding which lamp in the Christmas decorations has blown or become disconnected, causing the whole chain not to light.

As if this were not enough, it can even be used to test light bulbs, fuses and relay coils for continuity.

CIRCUIT DIAGRAM

The circuit diagram for the Live Wire Detector is shown in Fig.22. It is basically a very high gain amplifier, although no attempt has been made to minimise signal distortion. Indeed, it is not even biased, so it amplifies only the positive part of the sinusoidal mains frequency signal.

The fact that no base bias current is used is an advantage here. It means that when the circuit is not actively being used it draws no significant current, and so an on/off switch is not required.

The electric field, which exists around any conductor connected to an a.c. source, is remotely picked up by a short aerial wire or a small plate (such as a drawing pin) that is connected to the base of transistor TR1. This field, which will exist even if the conductor is not actually carrying a current, will induce a voltage at the transistor base (b) causing it to turn on.

The alternating base current will, of course, be minute as the effective impedance in the base circuit (which consists of the stray capacitance between the conductor and the detector probe) is very high and the collector current is therefore very small.

The collector current, however, provides the base current for transistor TR2. The currents at the emitter (e) of TR1 and the collector (c) of TR2, jointly provide the base current for TR3. In effect, the three transistors form a super transistor, which has a gain equal to the product of their individual gains.

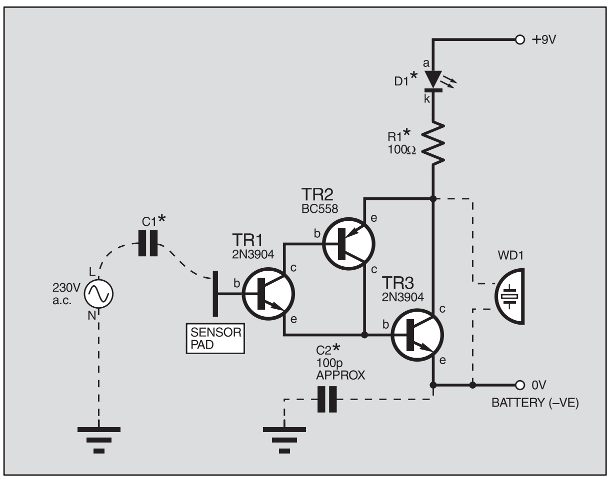


Fig.22. Circuit diagram for the Live Wire Detector.

The resulting current passing through TR3 via resistor R1 and l.e.d. D1, is large enough to light the l.e.d. Resistor R1 is included to limit the current. In fact, the l.e.d. flickers at the frequency of the electrical field source, at 50Hz for the UK mains supply (60Hz for USA). This is because TR1 is only turned on when the voltage on its base goes positive, but this is too fast to be noticeable visually.

The effect can be used to advantage. By connecting a piezo sounder or high-impedance earpiece between the collector and emitter of transistor TR3, an audio indication of the presence of mains fields can be provided, in the form of a 50Hz buzz (60Hz in USA). If this is preferred to a visual indication, then the l.e.d. can be replaced by a link wire and the value of resistor R1 increased to 10k. A louder sound output will also result.

The l.e.d. will only be turned on when the sensor is brought close to the live conductor in a mains cable, enabling it to be easily identified. When the sensor is removed from near the cable, the l.e.d. will be turned off. The circuit's earth is effectively provided by the capacitance of the mains circuit supply to the user's hand, and the user's body capacitance to earth, which is around 100pF (depending on body size!).

Gluing aluminium foil to the inside of the plastic case and connecting it to the battery negative can increase the hand capacitance effect, although this is not usually necessary. These stray capacitances

COMPONENTS

See SHOP TALK page

Resistor

R1	100Ω

Semiconductors

D1	red l.e.d., 5mm
TR1, TR3	2N3904 *npn* transistor (2 off)
TR2	BC558 *pnp* transistor

Miscellaneous

WD1	piezo sounder or high impedance earpiece

Stripboard, 8 holes x 8 strips; drawing pin (see text); PP3 9V battery; PP3 battery clip; plastic case to suit; connecting wire; solder, etc.

Approx. Cost Guidance Only **£3** *excl. case and battery*

are shown in Fig.22 as capacitor C1 and C2, illustrating how stray capacitance, which can be a problem in many high gain and high frequency circuits, can sometimes be used to advantage.

Note that the mains Neutral is approximately at Earth potential, although it is not connected to it.

CONSTRUCTION

The circuit is built on a piece of stripboard, as shown in Fig.23. There are no track cuts required. Ensure that the transistors and l.e.d. are correctly orientated.

The piezo sounder, or earpiece, can be connected directly to the stripboard, or a suitable jack plug and socket arrangement can be used, as has been shown in previous designs in this series.

Mount the circuit inside a small plastic box, size and shape of your choosing, but which should be large enough to house the battery.

USING THE UNIT

The unit will perform many useful functions and can even replace a multimeter in some instances, especially if only a go/no go display is required. Bringing the sensor close to a live conductor will be indicated by the l.e.d. lighting. This can be used to identify the live conductor in a cable without the need for an electrical contact, as is generally the case with a neon type mains tester. **Do not use it close to an uninsulated live mains carrying conductor**.

The live terminal of a mains outlet socket can also be checked to ensure that it has been wired correctly. If the socket is fitted with an on/off switch, this should be switched on. Bringing the unit close to the N or E terminals should not cause the l.e.d. to turn on, but bringing it close to the terminal should.

FUSE CHECKER

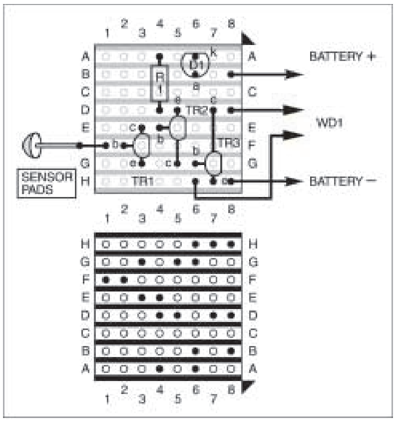
The unit is also very useful in checking if the fuse in a mains plug is serviceable, without the bother of dismantling the plug or unplugging the appliance. This should be the first thing that should be checked when confronted by an apparently faulty appliance. It can be done simply by using this Live Wire Detector to check if the cable between the plug and appliance is live when the appliance is plugged in.

A blown fuse will be indicated by the l.e.d. not lighting, as will a disconnected live wire in the plug. Unfortunately, a disconnected neutral wire will not be revealed by this unit so that a visual inspection may be required, although disconnected wires in modern factory fitted moulded plugs are most unlikely.

LIGHTS CHECK

Older style Christmas Tree lights consist of a number of series-connected low voltage lamps (normally 20 × 12V or 40 × 6V) connected across the 230V mains supply. Any one of these failing open circuit or becoming disconnected will cause the whole chain to fail. Discovering the offending bulb can mean disconnecting, checking and reconnecting each bulb in turn. Murphy's Law ensures that it is usually one of the last bulbs checked which will be found to be the cause!

The chain is usually connected (starting at the plug) with a wire from the L terminal to the first bulb, the other end of which



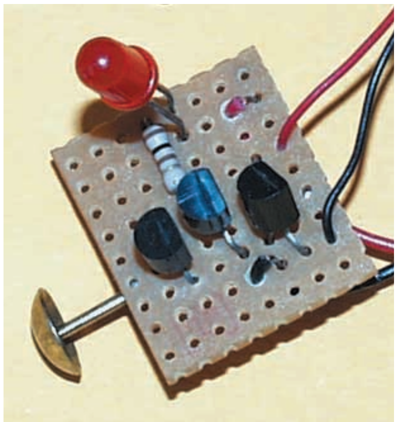


Fig.23. Live Wire Detector stripboard component layout and completed prototype circuit board. Note there are no breaks in the underside copper strips.

is connected by a short wire to the next bulb and so on down the chain with a long wire (twisted around the other wires) from the last bulb back to the N terminal in the plug.

If, say, the fourth bulb is faulty or has become disconnected, bringing the sensor close to the first, second, third and fourth bulbs in turn will cause the l.e.d. to light. But the l.e.d. will not light after the fourth bulb, indicating a fault there.

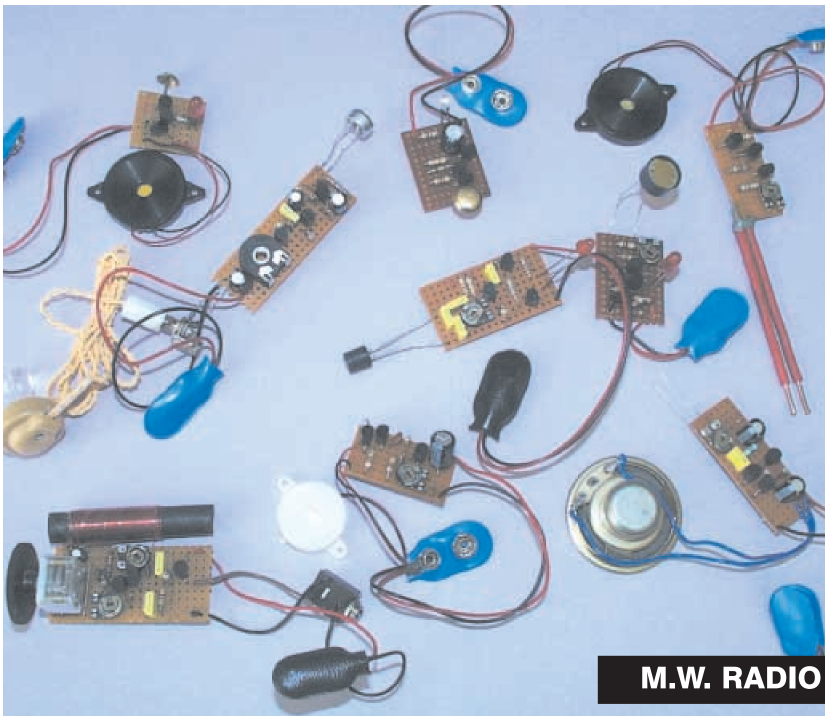
Where the conductors are twisted, it may be found that the circuit only responds along certain sections of the cable. This is because at various places the Live wire will be shielded from the sensor by the other conductor. It is important, therefore, to check along a good length of cable in case this effect gives the impression that a cable is not live when it is.

Bringing the sensor close to an earthed appliance should also not light the l.e.d. unless the earth cable is disconnected or broken so that this unit can also be used to check this.

TAKE CARE

It is clear that a non-lighting l.e.d. does not mean that a cable is safe as this could be due to the above shielding effect, or a poor sensor circuit Earth (if the user is on a ladder for instance). It could even be due to detector's battery being disconnected or exhausted! It is therefore most important that the unit is checked on a known live cable, or by touching the sensor, to ensure that the l.e.d. is operating, before testing an unknown conductor.

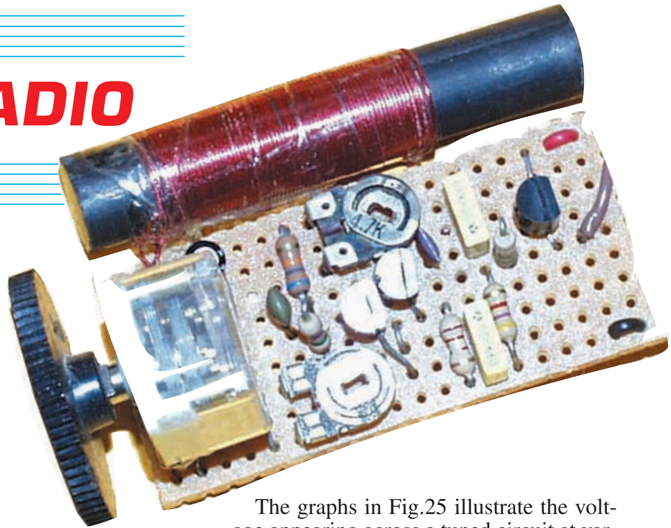
It will be noticed that touching the sensor normally only lights the l.e.d. briefly if the unit is held in the hand. If it is placed on an insulating surface, especially in a region with a high mains field (anywhere near a live conductor), it will glow brightly. This behaviour can be used to test light bulbs, fuses etc., by touching the sensor plate with one terminal of the component while holding the other in your hand. A blown fuse or bulb will not light the l.e.d., allowing continuity to be checked.



M.W. RADIO

Some of the simple transistor-based circuit assemblies described in this series.

MEDIUM WAVE RADIO



No series about transistor circuits would be complete without a simple radio circuit and, although better performance is obtainable using integrated circuits, simple radios are still fun to build and use and have been popular since the first transistors were introduced, well over 50 years ago.

RADIO RULES

Before describing the operation of this circuit, it may be useful to review a few basic principles which govern radio transmission. Aerials (both transmitting and receiving) are much more efficient when their length is comparable to the wavelength of the signal to be used.

Since wavelength is inversely proportional to frequency, it is clear that lower frequencies require longer aerials. It is, therefore, impractical to try to transmit audio signals directly as this would require aerials several hundred kilometres long, so most radio transmissions are restricted to higher frequencies, above a few hundred kilohertz.

CARRY ON

To transmit any useful information (e.g. speech or music) this high frequency, which is called the *carrier frequency* must be modulated and various schemes exist for doing so. Frequency modulation (f.m.), where the frequency of the carrier is varied by the audio signal, is the most widely used for hi-fi transmissions, although amplitude modulation (a.m.) is still popular where lower quality is acceptable.

This is probably due to the ease with which an a.m. radio signal can be *demodulated* and the audio signal recovered. The use of a carrier also has the great advantage of permitting simultaneous transmission by a large number of radio stations, each on a different frequency, while still allowing the listener to tune into one particular station.

In Fig.24 is shown a high frequency carrier which is amplitude modulated by a low frequency signal. In this case it is a sine wave, although it would more likely be a complex speech or music waveform. To receive this, a circuit that responds only to the carrier frequency (or a small range of frequencies around it) is required and here the tuned circuit, which we illustrated in the *Metal Detector* project (Part 2, March '03), can be used.

TUNED CIRCUIT

A tuned circuit has a low impedance at all frequencies except its resonant frequency (which is determined by the value of the inductor and capacitor used) so that all signals appearing at the aerial will be short circuited to earth, except the frequency to which the circuit is tuned.

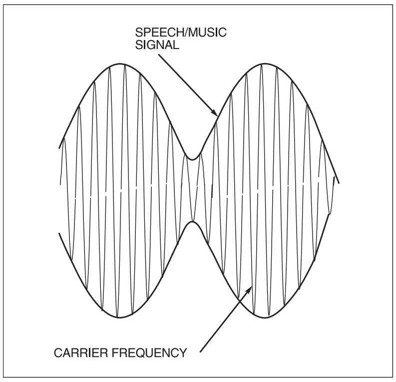


Fig.24. The make-up of an amplitude modulated (a.m.) radio signal.

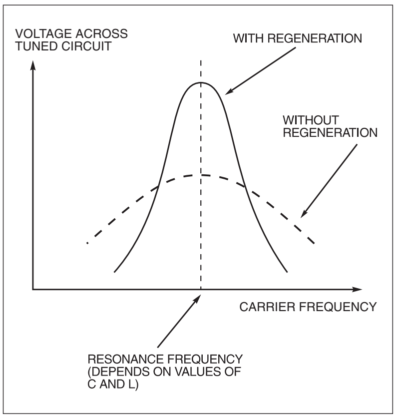


Fig.25. Frequency response of a tuned circuit.

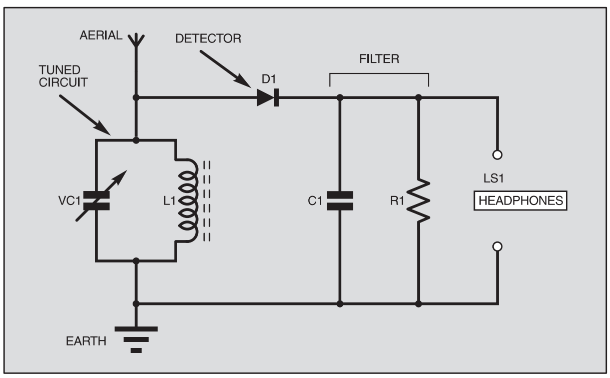


Fig.26. Basic radio receiver circuit.

The graphs in Fig.25 illustrate the voltage appearing across a tuned circuit at various frequencies. It will be seen that the voltage falls away gradually as the applied carrier frequency differs from the resonant frequency of the tuned circuit. Thus if all transmissions on all frequencies had an equal amplitude, the one coinciding with the resonant frequency would produce the largest output.

This is, of course, not the case as some transmitters radiate at lower power or are further away, resulting in a lower voltage at the receiver. For the best results it is clear that the peak response should be as "sharp" as possible to achieve maximum suppression of unwanted signals. This is governed by losses inherent in the tuned circuit and the smaller these are, the sharper will be the response.

BASIC CIRCUIT

A simple radio receiver circuit diagram is shown in Fig.26. The tuned circuit is formed by an inductor, L1, and a variable capacitor, VC1. The latter enables a range of frequencies to be tuned in.

Assuming the transmitted signal is that in Fig.24, the signal appearing across the tuned circuit will be identical. To recover the audio signal, the received signal must be demodulated. This can be done with a single diode, D1, which allows only the positive portion of the signal to pass. It is followed by a simple filter, consisting of capacitor C1 and resistor R1, which removes the high frequency carrier signal, leaving only the audio signal, which can be listened to via suitable headphones.

Given a long aerial and a good earth connection, together with very sensitive headphones, you may just about be able to receive a strong local a.m. station using this circuit. For a portable radio, however, it is useless, but it gives an idea of what is required to make a radio.

IMPROVEMENTS

Aerial signals smaller than the forward voltage of the diode (about 0·6V for a silicon diode) will not be passed to the headphones so the sensitivity of the circuit must be improved to allow weaker stations to be received.

The problem with using only one tuned circuit is that its response is too "flat" and with today's crowded wavebands, it is

difficult to select only one station and stronger stations transmitting on an adjacent frequencies to that required can interfere with reception. To improve the selectivity, commercial receivers use many more tuned circuits, but this leads to other problems that need much more complex circuits to resolve.

SENSITIVITY

The sensitivity of the radio can be improved simply by amplifying the aerial signal before it is fed to the detector, while to improve the selectivity, the losses inherent in the tuned circuit must be minimised to sharpen its response. As a first step, any impedance connected across the tuned circuit must be made high to load the tuned circuit as little as possible. Consequently the input impedance of the amplifier must be high.

The tuned circuit is coupled to the base of transistor TR1 by capacitor C1. The latter prevents the d.c. conditions from being upset by the low resistance of L1. The input impedance of this stage is high due to the large value bias resistor R2 and the resistance in the emitter circuit, provided by preset potentiometer VR1, so that the tuned circuit is only lightly loaded.

The circuit around transistor TR1 is very reminiscent of that used in the Metal Detector referred to earlier, in which the first transistor operated as an oscillator. Potentiometer VR1 is adjusted so that there is *just* insufficient positive feedback to sustain oscillation.

As the frequency to which the circuit is tuned increases, this feedback also increases but since the input impedance falls, the losses in the tuned circuit increase so that the circuit remains stable and VR1 should not need to be constantly re-adjusted.

COMPONENTS

Resistors

R1	68k
R2	4M7
R3	2k2
R4	1M5
R5	4k7

See **SHOP TALK** page

Potentiometers

VR1	1k skeleton preset
VR2	47k skeleton preset

Capacitors

C1	47p ceramic
C2	100p ceramic
C3, C4	100n polyester (2 off)
C5	10μ radial elect. 25V
VC1	15p to 165p variable capacitor

Semiconductors

TR1, TR2	2N3904 *npn* transistor (2 off)
TR3	BC558 *pnp* transistor

Miscellaneous

L1	Ferrite rod, 50mm x 10mm, with coil (see text)
LS1	high impedance earpiece

Stripboard, 19 holes x 9 strips; PP3 9V battery; PP3 battery clip; plastic case to suit; 28swg enamelled copper wire; solder, etc.

Approx. Cost Guidance Only **£5**
excl. case, earpiece and battery

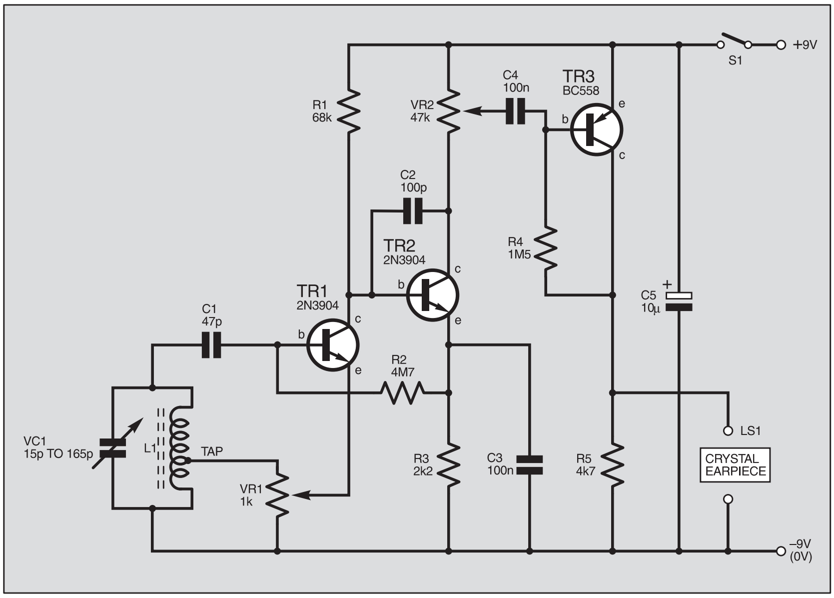


Fig.27. Practical circuit diagram for the Medium Wave Radio.

Another thing that can be done is to try to replace some of the tuned circuit losses by using positive feedback. However, this can lead to oscillation, and so the feedback level must be closely controlled. It is found that the selectivity is greatly improved if the circuit is just on the verge of oscillation.

Most circuits using this technique (which was called *regeneration* in old valve receivers) have a separate control to do this, but which is tricky to use, having to be adjusted for each station and is the reason why no modern commercial radios use it. With careful adjustment, though, it is possible to do away with this control and ensure that once set up, no further adjustment is required.

PRACTICAL CIRCUIT

The circuit diagram for a suitable receiver is shown in Fig.27. As in Fig.26, the tuned circuit is formed by inductor L1 and variable capacitor VC1. The coil acts not only as an inductor but also an aerial and the directional properties of the ferrite rod on which it is wound can also be useful to help eliminate unwanted stations from interfering with reception.

Transistor TR1 amplifies the signal appearing across the tuned circuit, boosting the sensitivity of the circuit and eliminating the need for an earth connection. No separate detector diode is used in this design as this function is carried out by the collector (c) of TR1.

Transistor TR2 further amplifies the signal but the gain at high frequency is very low due to the presence of capacitor C2, so that only the audio signal is amplified while the residual radio frequency carrier signal is suppressed. Using d.c. negative feedback via R2 stabilises the operating point of the two transistors, while capacitor C3 bypasses TR2's emitter resistor, R3, so increasing the gain of this stage at audio frequencies.

The collector load consists of potentiometer VR2, which forms a volume control enabling the signal level to TR3, the earpiece driver, to be varied.

CONSTRUCTION

The circuit is constructed on stripboard, as shown in Fig.28. Care must be taken to ensure that stray capacitance is minimised by keeping component leads as short as possible.

Aerial coil L1 is made by winding 10 turns of 28s.w.g. enamelled wire onto a

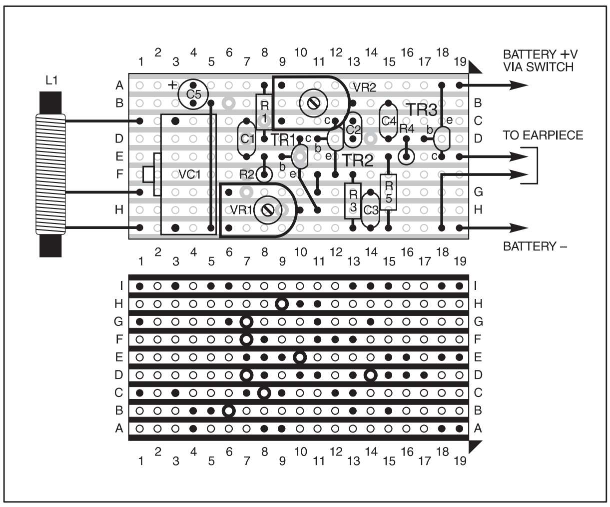
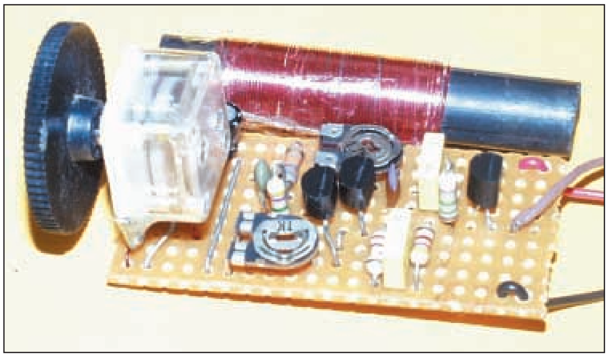


Fig.28. Radio stripboard component layout, wiring and details of breaks required in the underside copper tracks.



Completed radio showing the ferrite rod aerial.

Starting Next Month . . .
. . . RADIO CIRCUITS

Intended to dispel the mysteries of radio, this short series of articles by Raymond Haigh features a variety of circuits for the set builder and experimenter.
This new series will view the technology in an historical perspective and try to dispel its mysteries. The main purpose, however, is to present a variety of practical circuits.
You will be able to build a wide range of receivers, everything from a crystal set to a superhet.

piece of ferrite rod, 50mm long and 10mm in diameter. This forms the feedback winding and should be followed by a further 60 turns to form the main coil.

Each turn should be made adjacent to the previous one and the whole winding should be secured to the ferrite rod with insulation tape. The final number of turns may need to be adjusted (up or down) depending on the actual capacitance range of variable capacitor VC1, which is used to obtain the required medium waveband coverage.

Since it is easier to remove turns than to add them once the wire has been cut to length, it is preferable to initially wind slightly more turns than required.

A miniature tuning capacitor was used in the prototype for VC1, with a value range of 15pF to 165pF. The actual range is not too critical as most values can be accommodated by varying the number of turns on the coil, as just said, and/or connecting fixed capacitors across VC1 to adjust the range span.

TUNING CHECKS

Once construction is finished, VR1 and VR2 should be turned fully clockwise and a battery connected. Adjust VC1 until a station is heard and then adjust the signal amplitude using VR1. If the circuit oscillates (which is heard as a high pitched whistle in the earpiece) turn VR1 back slightly.

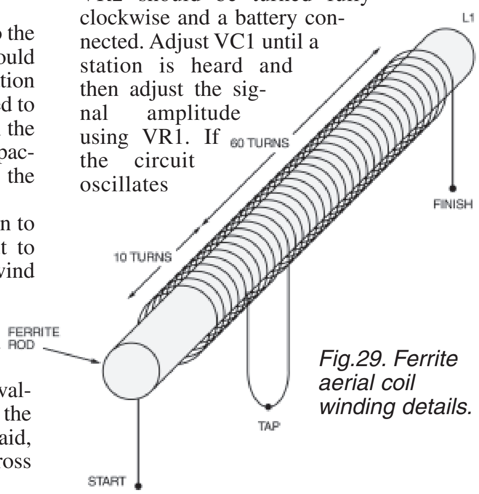


Fig.29. Ferrite aerial coil winding details.

Turn VC1 fully clockwise and check that no oscillation occurs on other stations, re-adjusting VR1 if required. The circuit should now not oscillate, irrespective of which station is tuned in.

The circuit will draw about 2mA, so an on/off switch is required. Alternatively, a 3·5mm stereo jack socket can be fitted for the earpiece with the tip terminal connected to TR3's collector, the centre terminal connected to the circuit's 0V line (marked as Battery –V). The battery negative itself is then connected to the outer terminal.

Inserting the earpiece plug will short out these last two terminals, switching on the power to the circuit. The principle is similar to that in Fig.7 of Part 1, Feb. '03.

In the concluding part of this series, next month, we describe a Twilight Switch, and a simple circuit for that most fascinating of all musical instruments – the Theremin.

SHOP TALK
with David Barrington

Super Motion Sensor

Nearly all of the "miniature" light-dependent resistors we looked up in various components catalogues seem to be within the specification required for the *Super Motion Sensor* project. A suitable l.d.r. should certainly be stocked by many of our components advertisers.

The 12V relay used for this project **must** have switching contacts rated for the appliance it is going to be controlling. This may mean that it will not sit directly on the circuit board so you will have to mount it separately and "hard wire" the relay to the p.c.b.'s appropriate copper pads. The Telecom type, mentioned by the author, should be widely available, but do not forget to check the contact ratings before purchase.

The TL071 low noise, low distortion op.amp is a popular device and should not present any buying problems. It was selected particularly for its high input impedances, which are necessary for this circuit. The 4066 quad bilateral switch i.c. is another popular widely-stocked device.

The Sensor printed circuit board is available from the *EPE PCB Service*, code 391 (see page 359).

Back-To-Basics 4 – Live Wire Detector/M.W. Radio

Some readers may experience problems with a couple of parts for the *Medium Wave Radio*, one of this month's *Back-To-Basics* projects.

Most components suppliers carry a 100mm length by 10mm diameter ferrite rod, which means readers will have to cut it to size. One problem, ferrite is very brittle and great care will be needed when cutting this material. One suggestion is to score around the rod diameter, at the required length, and then give it a "gentle" tap to snap it apart. We see that **WCN Supplies** (☎ ***023 8066 0700***) are currently "advertising" a 140mm x 10mm ferrite rod, with an unwanted tuning coil, at a reasonable price.

The specified tuning capacitor is normally found listed as a miniature "transistor radio" type. However, the favourite value is 20pF to 126pF, which should be OK for this simple radio. One was found listed by **ESR Components** (☎ ***0191 251 4363*** or ***www.esr.co.uk***), code 896-110.

No component problems should be met with the *Live Wire Detector*, the second simple project this month.

Door Chime

The audio amplifier i.c. chosen for the *Door Chime* project is the TDA7052 power amp chip which, in fact, contains two amplifiers in a single 8-pin d.i.l. package. This device is widely held and should not present any buying difficulties. You should certainly give ***Cricklewood Electronics*** (☎ ***020 8452 0161***) a call as we understand they have stocks.

The rest of the components are standard "off-the-shelf" items. Your local DIY superstore should have a suitable front doorbell pushswitch, if you do not already have one, of course. The small printed circuit board is available from the *EPE PCB Service*, code 390 (see page 359).

PLEASE TAKE NOTE

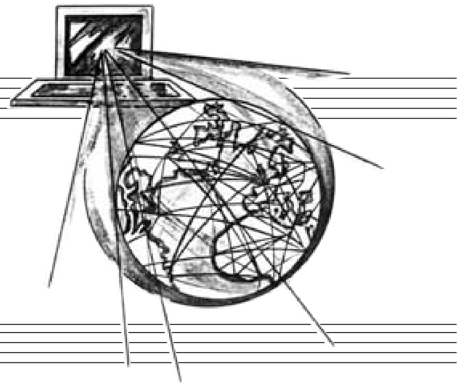
Earth Resistivity Logger *(April '03)*

Page 292. The wrong operating frequency for the crystal X1 is listed in the Components box. This should be 3·6864MHz. The circuit diagram Fig.5 and text are correct.

Shoptalk *(April '03)*

We regret that we gave an incorrect telephone number for Farnell and that it should be 0113 263 63**11**. You can also use 0870 1200 200.

SURFING THE INTERNET



NET WORK

ALAN WINSTANLEY

It's a Steal

In last month's column the auction web site eBay (**www.ebay.co.uk** – or select your own country's web site) was described in further detail. eBay enables its members to sell a huge variety of products in its auctions, which run for a preset period that is timed accurately to the second.

When bidding for an item, it can be infuriating to lose the auction when a competing higher bid is entered just a few seconds before the auction closes. This is especially the case when struggling with dial-up access, as it is impossible to refresh the screen more than once or twice within the closing minute of the auction.

One way of clinching a deal is to place an earlier bid that is sufficiently high enough that no-one else will want to beat it; provided that a realistic grip is kept on the likely value of the item and you don't get too carried away with bidding, you can hopefully frustrate any competing bids if you pitch yours sensibly. (As an example of getting carried along with the bidding, the author recently noticed a copy of Adobe Photoshop 7.0 that sold for £460.00, which is fast approaching the maximum full retail price on the High Street, and nearly 40% above a typical eBay price.)

There is no substitute, though, for trumping the deal with your own bid placed only a few seconds before bidding is due to close. This last-moment winning bid is known as "sniping" and to the uninitiated eBayer, losing an auction to a "sniper" can be infuriating! To the sniper though, such a victory can be immensely satisfying!

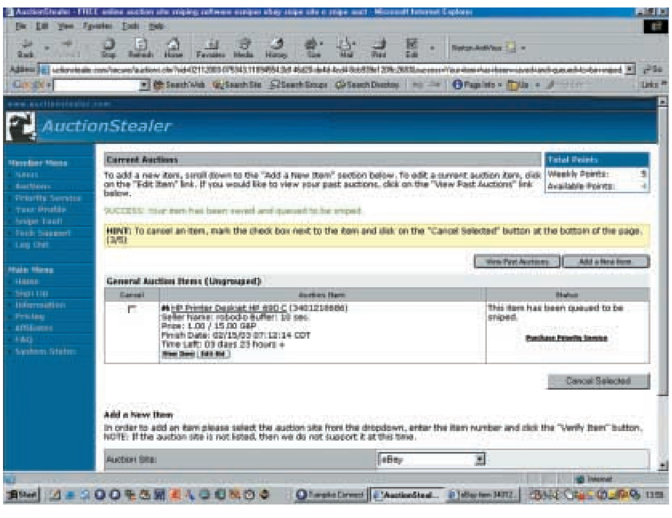
On the Line

The trick to successful sniping is to use an online bidding service. A search on Google for *auction stealing* or *auction sniping* will highlight a number of web sites that provide this service such as that offered by Auctionstealer (**www.auctionstealer.com** or **www.auctionstealer.co.uk**).

The service places a bid automatically on your behalf during the final few moments of an auction (note that some sniping services appear to use software running on your computer instead). This also relieves you of the onerous task of having to be present at your computer in order to place your bid just before closing time.

The Auctionstealer system is easy to use and works like magic: simply create a username and password, and then enter the number of the eBay item you are interested in, together with your maximum bid. As a free service, Auctionstealer will then enter your own bid ten seconds before the auction closes.

For low value items, this is a great way of having your bids entered automatically, without any need to watch the bidding for yourself. The process is seamless with the eBay auction site, so it appears to eBay that you have placed a bid just as you usually do. However the ten-second period does still offer scope for being outbid by others.



Auctionstealer allows last-second bids to be made.

Premium Service

If you are keen to win what might be described as a particularly "juicy-looking" item, then Auctionstealer offers a paid-for premium service starting with a $1 fee per item, that will enter your bid just *three seconds* before closure. This leaves no time for anyone else to respond to your bid (unless another sniper has bid a higher price) and it has resulted in some wonderful deals being struck! The paid-for service also extends to monthly subscriptions for frequent bidders if desired.

Payment is made by Paypal; in fact in the author's case, buying a series of $1 bids by Paypal resulted in the writer's credit card being locked by Visa, who viewed the series of small Internet transactions with suspicion. This became apparent when a major Internet purchase of a new TV was made the next day, because the credit card transaction was declined.

Overall, a combination of eBay's web site and Auctionstealer has produced a number of valuable "finds" and it's worth bookmarking both sites for future use.

Paying the Paypal Way

The problem mentioned above regarding credit card processing, which resulted in the writer's credit card being frozen, highlights the fact that trading on the Internet is becoming ever more difficult, mainly due to the increased security measures that the credit card companies and banks have put into place. In the UK it is not easy for new businesses to open an Internet merchant account anyway, so they may not be able to accept CC payments during their start-up phase.

Buyers and consumers should also be aware of the conditions now imposed by the credit card companies concerning the use of their credit card via the Internet. In particular, many CC providers, who demand that only a secure server be used for payments, expressly prohibit customers from sending a credit card number by open email (something that is very unwise to do anyway).

The writer recorded three $1 payments to Paypal, then to make doubly sure that the subsequent Internet purchase of a TV was indeed genuine, the writer had to confirm this to Visa by phone, and they still sent a letter seeking further confirmation that the transaction was indeed genuine. The security of financial systems is being tightened up everywhere, to stamp out fraud and money-laundering.

Paypal (**www.paypal.com**) is the ubiquitous online credit card processing service now owned by eBay, which boasts of having 20 million registered users. The system sounds easy enough but is full of pitfalls for the unwary user or business owner. For example, their web site states "You can pay anyone with an email address . . . even if they don't have a Paypal account." ". . . The money will be sent directly to your recipient . . ."

Sounds easy enough, but is it? Next month we look more closely at Paypal and highlight some of the potential problems that exist when doing business the Paypal way. If you have your own Paypal story to tell or would like to comment, you can email me at **alan@epemag.demon.co.uk**. See you next month.

PRACTICALLY SPEAKING

Robert Penfold looks at the Techniques of Actually Doing It!

ONE of the most common requests for help comes from readers who have gained some experience at building projects, and wish to move on to designing their own circuit boards. As to be expected there is a natural need for a progression from cloning published projects to a more "do your own thing" approach. Some wish to substantially modify existing designs or merge them, but the primary aim of most is to build from published circuits.

There are plenty of circuits published in books, on the Internet, and in *EPE's Ingenuity Unlimited* pages. In order to turn one of these into a working project it is necessary to work out your own circuit layout using stripboard, a custom printed circuit board, or whatever.

A custom printed circuit board certainly gives the neatest results. Designing and building their own printed circuit boards is something that many electronic project builders undertake routinely, but it is not the best place to start. Initially, it is better to use a simpler and more direct method that involves fewer skills and processes.

Stripboard is by far the most popular choice, but it would be a mistake to overlook plain matrix board. This was once a popular construction method, but these days it is mainly used for testing prototype circuits rather than for final construction.

Hole Truth

Plain matrix board is essentially stripboard minus the underside copper strips. There are expensive wiring systems available that utilize this type of board, but again, these are really aimed at the production of commercial prototypes.

Some solder, a plain matrix board and some single strand wire is all that is needed for project building. The general scheme of things is to fit the components onto the board in much the same way as for a custom board or stripboard.

However, instead of the leads being cut short and soldered to copper tracks on the underside of the board, they are bent over at right angles and used to carry the interconnections (see Fig.1). In other words, the leadout wires are used to replace the copper tracks of a normal printed circuit board.

Some modern components, such as integrated circuits and many capacitors, have pins instead of leadout wires. In other cases the component leads may simply be too short. In either case some 22s.w.g. or 24s.w.g. tinned copper wire can be used to bridge any gaps in the wiring.

If necessary, interconnections can be carried on the top side of the board by threading the wire up through one hole in the board and then back down through another. This is the equivalent of a double-side printed circuit board or link-wires used on a stripboard, and it enables wires to cross without touching.

Plainly Speaking

Although no one is ever going to accuse plain matrix construction of looking particularly neat, this method of construction can have definite advantages. When designing any form of board layout it is important to bear in mind that there are stray couplings from one part of a circuit to another.

There can be inductive couplings, but it is coupling through stray capacitance that is the major problem in most cases. For instance, a capacitor is simply two pieces of metal separated by a layer of insulation, so two pieces of wire with air in between constitute a capacitor. Two copper tracks running side by side on a printed circuit board or a stripboard can also act as a capacitor.

The values involved are tiny, but a very small amount of capacitance in the wrong place can be sufficient to produce instability or other problems. The problem is most acute with circuits that involve large amounts of amplification and (or) operate at high frequencies.

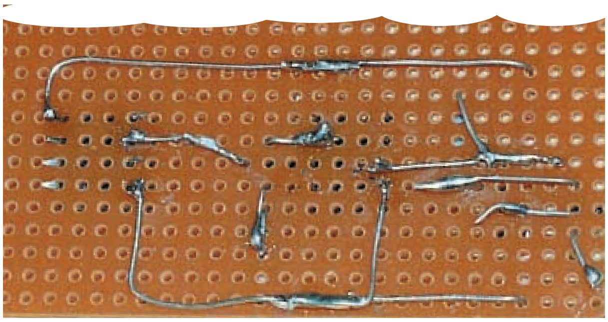


Fig.1. Plain matrix construction is not particularly neat but it is simple and efficient.

Going Astray

The stray capacitance problem is worst with stripboard because it has numerous copper tracks running the full length of the board, which produces a large number of built-in capacitors that are relatively high in value. There are ways of minimising the problem, such as making cuts in the strips to isolate unused pieces, or even peeling away unused bits of copper strip. An earthed strip can act as a screen between parts of a circuit where stray feedback could be a problem.

It can be a struggle to get some H.F. circuits to work on stripboard, and there is no guarantee of success. Plain matrix board does not eliminate these problems, but it keeps them to an absolute minimum. It is the equal of a custom printed circuit board in this respect.

Practically any type of project can be constructed on plain boards, but it can be awkward to use with some types of circuit. The main problem area is digital circuits that use numerous digital chips with huge numbers of interconnections.

This type of thing can be accommodated by plain matrix construction, but it can be very time consuming and difficult to produce neat and reasonably compact layouts. Construction times can also be very long.

The popularity of microcontrollers means that traditional digital circuits of this type are now something of a rarity, so the plain matrix approach is applicable to most modern circuits.

Initial Placements

Probably the most difficult part of designing board layouts is knowing where to start. This is almost certain to be a major sticking point for someone trying their first few board designs.

Initially, try a couple of board layouts for very simple projects. They can be done as pure exercises if there are no simple projects that you wish to build.

The circuit diagram shown in Fig.2 was featured in an *Interface* article, and it is designed to produce a low current +5V output from a PC printer port. This type of single chip circuit is ideal for initial attempts at board design.

A CAD program and a PC are ideal for drawing up this type of thing. All these programs can produce a grid of dots on the screen to aid the placement of lines and shapes, and the dots can be used to represent the holes in the board. Many people use graph paper when drawing up designs on paper, but drawing up your own chunkier version on plain paper using something like a 4H pencil is a better alternative.

Plain matrix board has the holes drilled on the usual 0·1 inch (2·54mm) matrix, but it easier is to see everything clearly if the designs are drawn at double life size. Initially anyway, draw the design as a top view only. Connecting wires can be represented as dashed lines, or drawn using a different colour to the one used for the top layer.

Getting Started

Start with a board outline that is definitely a lot wider than is required so that there is no risk of the design running out of space at one end. The height must have (say) five rows of holes to accommodate mounting holes, two for the supply rails, and sufficient rows between the supply rails for the circuit.

In the case of Fig.2, the 8-pin integrated circuit requires four rows, and

three or four rows should be included above and below to allow some room to manoeuvre. Making the board as small as possible is not a consideration, so four holes were used above and below the integrated circuit. This could be reduced to three or even two holes if space was limited.

Next the integrated circuit is drawn into place on its allotted rows of holes, somewhere near the middle of the board. The normal orientation for integrated circuits is with pin one at the top, but in this case the layout is likely to be easier with the chip the other way around (as indicated by the pin numbers).

With a custom printed circuit board it is possible to design a neat component layout and then join everything together with a complex track pattern. With plain matrix and stripboard construction it is better to "go with the flow", and use a component layout that gives simple and reasonably direct interconnections.

First Steps

The obvious first step is to draw the connections from IC1 to the supply rails, and in this case there are two pins that connect to the positive rail (pins 4 and 8). The simplest way of handling this is to add the supply connection for pin 4 and then add a connection between pins 4 and 8. The next step is to start adding the components to the design.

they are readily accessible. In the real thing these connections are made via solder pins on the board. The double-sided variety of pin is better for this method of construction, as these provide more for the wires on the underside of the board to be connected to.

You should end up with a design similar to that shown in Fig.4; without the deliberate mistakes. The unused areas at each end of the board have been erased and the two mounting holes have been added. Two are sufficient for small boards, but for larger boards it is advisable to use one near each corner.

Final Analysis

Even with a simple design it is advisable to put it to one side for half

There are several possible solutions to this, and one of them is simply to leave the design unchanged, but with insulating plastic sleeving added to one of the wires. The solder pin could be moved to just below D1, but this would move it away from the other input connections. Another option is to weave one of the wires onto the top side of the board, over the other wire, and then back down again.

Yet another option is to do some juggling with the basic design. This is quite easy if a CAD program is being used, and a modified design of Fig.4 is shown in Fig.5.

Avoid making numerous changes simply because it is easy to do so. It is easy to end up in a situation where

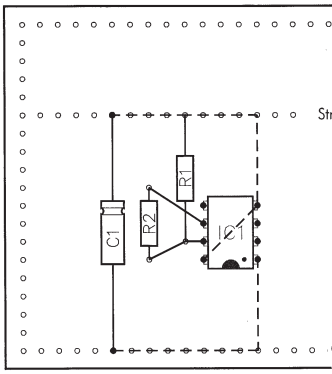


Fig.3. Initial design stages.

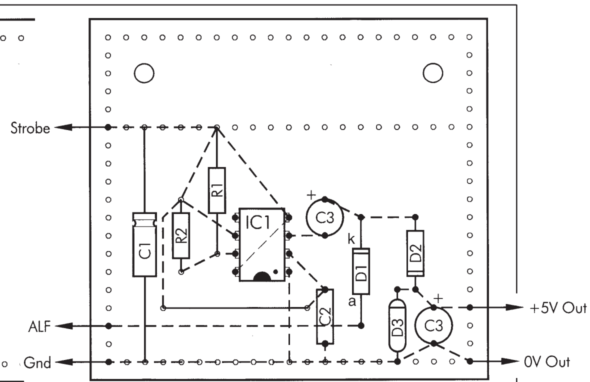


Fig.4. Finished but unchecked design – spot the "deliberate" mistakes.

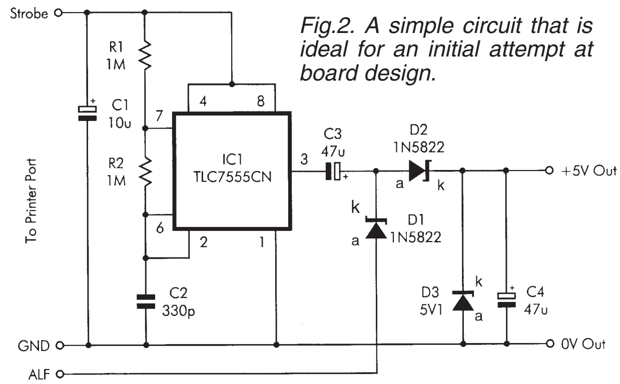


Fig.2. A simple circuit that is ideal for an initial attempt at board design.

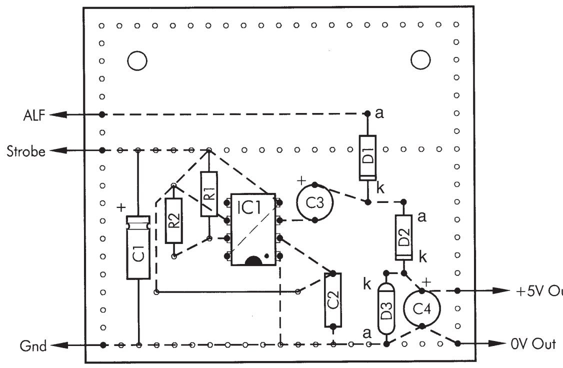


Fig.5. Corrected and, hopefully, working design.

It is best to start by adding the components that connect to the integrated circuit and gradually work outwards. Resistors R1 and R2 can be added to the left of IC1, and capacitor C1 can be added between the supply rails. This gives a layout something like that shown in Fig.3, but there is no single design that is right. There are usually numerous layouts that will give the desired set of interconnections.

The process continues with the components being added one by one, and linked to the rest of the design. The circuit diagram will usually act as a general guide to the physical layout, but it should not be slavishly followed. Have the components and a board handy when designing layouts on "paper". It is then easy to check that sufficient space is being left for each component.

Finally, the off-board connections are added, and they should preferably be at or near an edge of the board where

an hour or so and then give the design a thorough check. An advantage of this method of construction, and stripboard construction, is that any errors that make it through to the finished board can usually be corrected without too much trouble. A major blunder with a custom printed circuit board usually means building the whole thing again.

Even though errors are easily corrected it is better to get it right first time. Incorrect connections can cause expensive damage to the components, and there could be safety issues as well.

In the case of Fig.4, there are a couple of obvious errors. The capacitor labelled C3 near the bottom right-hand corner of the board is actually C4. More importantly, the wire from the anode (a) of diode D1 to the solder pin crosses the 0V supply connection to IC1, and would short-circuit to it.

two errors are added for each one that is corrected. In a similar vein, too much tidying up in an attempt to make the design "pretty" can add errors into what was previously a working layout.

Grand Designs

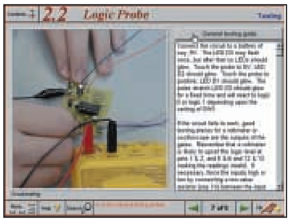
Producing layouts for larger circuits uses the same basic methods. Larger circuits break down into a number of circuit blocks, and with modern designs there is usually an integrated circuit at the heart of each block. Take things stage-by-stage, gradually building up the design.

Plain matrix board is not well suited to really large projects, but with small and medium sized circuits it represents an easy way of getting started with your own layouts. Unlike stripboard construction, it should work first time with temperamental circuits where stray capacitance can be a problem.

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS



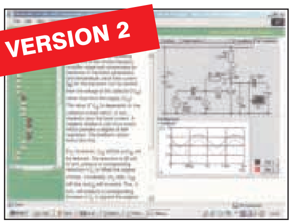
Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

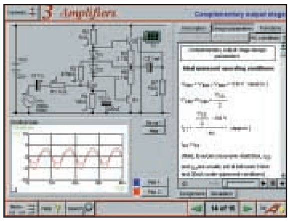
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS



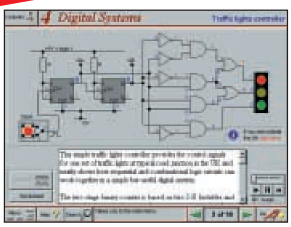
Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

VERSION 2

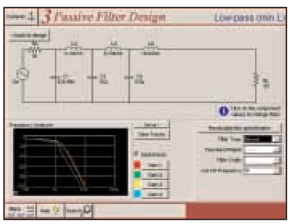


Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

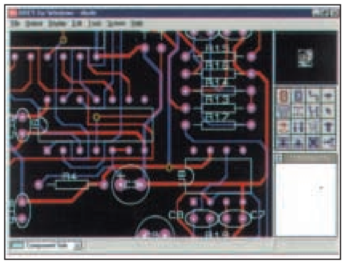
FILTERS



Filter synthesis

Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

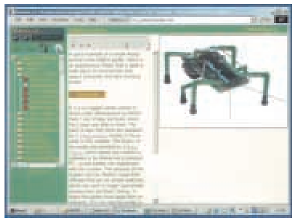
ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student ....£45 inc VAT
Institutional (Schools/HE/FE/Industry)..............£99 *plus* VAT
Institutional 10 user (Network Licence) ....£199 *plus* VAT
Site Licence...£499 *plus* VAT

(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

PICmicro TUTORIALS AND PROGRAMMING

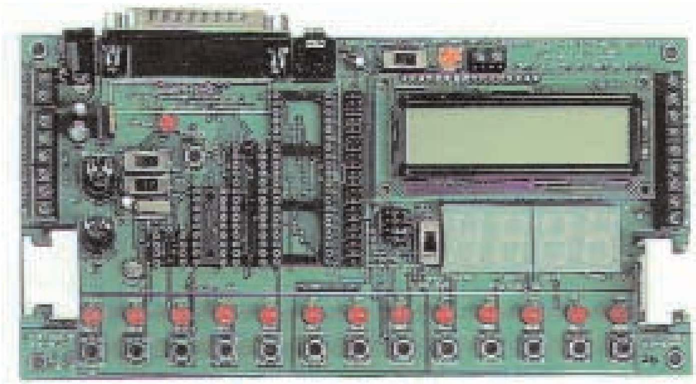
HARDWARE

VERSION 2 PICmicro MCU DEVELOPMENT BOARD

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 13 individual l.e.d.s, quad 7-segment display and alphanumeric l.c.d. display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- All inputs and outputs available on screw terminal connectors for easy connection



£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

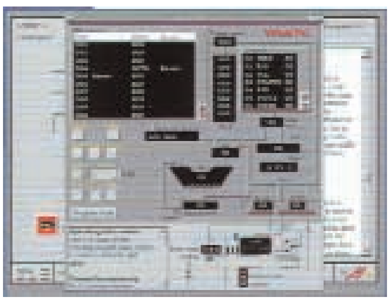
Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V2.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 39 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.



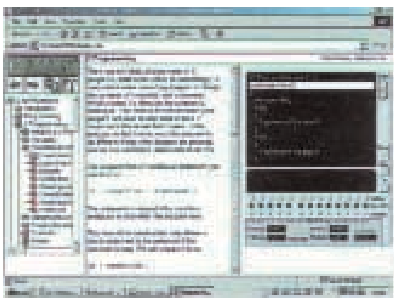
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

FLOWCODE FOR PICmicro

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 8, 18, 28 and 40-pin devices ● Institutional versions include virtual systems (burglar alarms, car parks etc.).

Burglar Alarm Simulation

PRICES

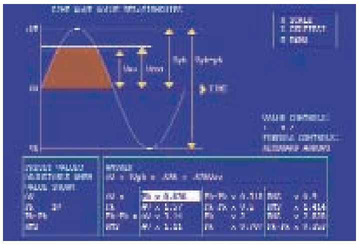
Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99 *plus* VAT**
Flowcode Institutional	**£70 *plus* VAT**
Institutional 10 user (Network Licence)	**£249 *plus* VAT**
Site Licence	**£599 *plus* VAT**

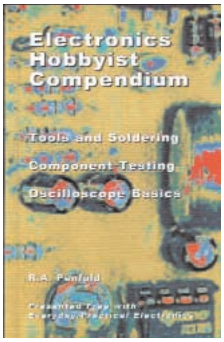
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

TEACH-IN 2000 – LEARN ELECTRONICS WITH EPE



Sine wave relationship values

FREE BOOK WITH TEACH-IN 2000 CD-ROM



EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering*. The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.

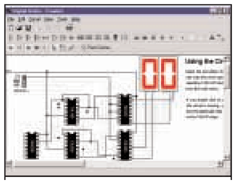
Each part has an associated practical section and the series includes a simple PC interface so you can use your PC as a basic oscilloscope with the various circuits.

A hands-on approach to electronics with numerous breadboard circuits to try out.

£12.45 including VAT and postage. Requires Adobe Acrobat (available free from the Internet – **www.adobe.com/acrobat**).

FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

Hobbyist/Student £45 inc. VAT.
Institutional £99 *plus* VAT.
Institutional 10 user £199 *plus* VAT.
Site Licence £499 *plus* VAT.

ELECTRONICS IN CONTROL

Two colourful animated courses for students on one CD-ROM. These cover Key Stage 3 and GCSE syllabuses. **Key Stage 3:** A pictorial look at the Electronics section featuring animations and video clips. Provides an ideal introduction or revision guide, including multi-choice questions with feedback. **GCSE:** Aimed at the Electronics in many Design & Technology courses, it covers many sections of GCSE Electronics. Provides an ideal revision guide with Homework Questions on each chapter. Worked answers with an access code are provided on a special website.

Single User £29 inc. VAT. Multiple User £39 plus VAT
Student copies (available only with a multiple user copy) £6 plus VAT
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

MODULAR CIRCUIT DESIGN

VERSION 3

Contains a range of tried and tested analogue and digital circuit modules, together with the knowledge to use and interface them. Thus allowing anyone with a basic understanding of circuit symbols to design and build their own projects. Version 3 includes data and circuit modules for a range of popular PICs; includes PICAXE circuits, the system which enables a PIC to be programmed without a programmer, and without removing it from the circuit. Shows where to obtain free software downloads to enable BASIC programming.

Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

Single User £19.95 inc. VAT. Multiple User £34 *plus* VAT
(UK and EU customers add VAT at 17.5% to "plus VAT" prices)

ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 JPG images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Also contains a **FREE** 30-day evaluation of Paint Shop Pro 6 – Paint Shop Pro image editing tips and on-line help included!

Price £19.95 inc. VAT

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

CD-ROM ORDER FORM

Please send me:

- ☐ **Electronic Projects**
- ☐ **Electronic Circuits & Components V2.0**
- ☐ **Analogue Electronics**
- ☐ **Digital Electronics V2.0**
- ☐ **Filters**
- ☐ **Electronics CAD Pack**
- ☐ **Robotics & Mechatronics**
- ☐ **Assembler for PICmicro**
- ☐ **'C' for PICmicro**
- ☐ **Flowcode for PICmicro**
- ☐ **Digital Works 3.0**

Version required:

- ☐ **Hobbyist/Student**
- ☐ **Institutional**
- ☐ **Institutional 10 user**
- ☐ **Site licence**

- ☐ **PICmicro Development Board (hardware)**
- ☐ **Development Board UK plugtop power supply**
- ☐ **Development Board 25-way connecting lead**

- ☐ **Teach-In 2000 + FREE BOOK**
- ☐ **Electronic Components Photos**
- ☐ **Electronics In Control – Single User**
- ☐ **Electronics In Control – Multiple User**
- ☐ **Modular Circuit Design – Single User**
- ☐ **Modular Circuit Design – Multiple User**

Note: The software on each version is the same, only the licence for use varies.

Full name: . . . .

Address: . . . .

. . . .

. . . . .Post code: . . . . .Tel. No: . . . .

Signature: . . . .

☐ I enclose cheque/PO in £ sterling payable to WIMBORNE PUBLISHING LTD for £ . . . .

☐ Please charge my Visa/Mastercard/Amex/Diners Club/Switch: £ . . . . . . .Card expiry date: . . . .

Card No: . . . . Switch Issue No. . . . .

Card Security Code . . . . (The last 3 digits on or just under the signature strip)

ORDERING

ALL PRICES INCLUDE UK POSTAGE

Student/Single User/Standard Version price includes postage to most countries in the world
EU residents outside the UK add £5 for airmail postage per order

Institutional, Multiple User and Deluxe Versions – overseas readers add £5 to the basic price of each order for airmail postage (**do not add VAT** unless you live in an EU (European Union) country, then add 17½% VAT or provide your official VAT registration number).

Send your order to:
Direct Book Service
Wimborne Publishing Ltd
408 Wimborne Road East
Ferndown, Dorset BH22 9ND

To order by phone ring
01202 873872. Fax: 01202 874562
Goods are normally sent within seven days
E-mail: orders@wimborne.co.uk
Online shop:
www.epemag.wimborne.co.uk/shopdoor.htm

PCB SERVICE

Printed circuit boards for most recent *EPE* constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for *airmail* outside of Europe. Remittances should be sent to **The PCB Service, *Everyday Practical Electronics*, Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown, Dorset BH22 9ND. Tel: 01202 873872; Fax 01202 874562; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.wimborne.co.uk/shopdoor.htm.** Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only).**
NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.
Back numbers or photostats of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.
A number of older boards are listed on our website.
Boards can only be supplied on a payment with order basis.

PROJECT TITLE		Order Code	Cost
Doorbell Extender: Transmitter	**MAR '01**	292	£4.20
Receiver		293	£4.60
Trans/Remote		294	£4.28
Rec./Relay		295	£4.92
EPE Snug-bug Heat Control for Pets	**APR '01**	296	£6.50
Camcorder Mixer	**MAY '01**	299	£6.34
★PIC Graphics L.C.D. Scope		300	£5.07
Hosepipe Controller	**JUNE '01**	301	£5.14
Magfield Monitor (Sensor Board)		302	£4.91
Dummy PIR Detector		303	£4.36
★PIC16F87x Extended Memory **Software only**		–	–
Stereo/Surround Sound Amplifier	**JULY '01**	304	£4.75
Perpetual Projects Uniboard–1		305	£3.00
Solar-Powered Power Supply & Voltage Reg.			
MSF Signal Repeater and Indicator			
Repeater Board		306	£4.75
Meter Board		307	£4.44
★PIC to Printer Interface		308	£5.39
Lead/Acid Battery Charger	**AUG '01**	309	£4.99
Shortwave Loop Aerial		310	£5.07
★Digitimer – Main Board		311	£6.50
– R.F. Board		312	£4.36
Perpetual Projects Uniboard–2			
L.E.D. Flasher — Double Door-Buzzer		305	£3.00
Perpetual Projects Uniboard–3	**SEPT 01**	305	£3.00
Loop Burglar Alarm, Touch-Switch Door-Light and Solar-Powered Rain Alarm			
L.E.D. Super Torches – Red Main		313 } Set	£6.10
– Display Red		314 } Set	
– White L.E.D.		315	£4.28
★Sync Clock Driver		316	£5.94
★Water Monitor		317	£4.91
Camcorder Power Supply	**OCT '01**	318	£5.94
PIC Toolkit Mk3		319	£8.24
Perpetual Projects Uniboard–4. Gate Sentinel, Solar-powered Bird Scarer and Solar-Powered Register		305	£3.00
Teach-In 2002 Power Supply	**NOV '01**	320	£4.28
Lights Needed Alert		321	£5.39
Pitch Switch		322	£5.87
Capacitance Meter – Main Board (double-sided)		323 } Set	£12.00
– Display Board (double-sided)		324 } Set	
★★PIC Toolkit TK3 – **Software only**		–	–
4-Channel Twinkling Lights	**DEC '01**	325	£6.82
Ghost Buster – Mic		326 } Set	£5.78
– Main		327 } Set	
★PIC Polywhatsit – Digital		328 } Set	£7.61
– Analogue		329 } Set	
Forever Flasher	**JAN '02**	330	£4.44
Time Delay Touch Switch		331	£4.60
★PIC Magick Musick		332	£5.87
Versatile Bench Power Supply		333	£5.71
★PIC Spectrum Analyser	**FEB '02**	334	£7.13
Versatile Current Monitor		335	£4.75
Guitar Practice Amp		336	£5.39
★PIC Virus Zapper	**MAR '02**	337	£4.75
RH Meter		338	£4.28
★PIC Mini-Enigma – **Software only**		–	–
★Programming PIC Interrupts – **Software only**		–	–
★PIC Controlled Intruder Alarm	**APR '02**	339	£6.50
★PIC Big Digit Display	**MAY '02**	341	£6.02
Washing Ready Indicator		342	£4.75
Audio Circuits–1 – LM386N-1		343	£4.28
– TDA7052		344	£4.12
– TBA820M		345	£4.44
– LM380N		346	£4.44
– TDA2003		347	£4.60
– Twin TDA2003		348	£4.75
World Lamp	**JUNE '02**	340	£5.71
Simple Audio Circuits–2 – Low, Med and High			
Input Impedance Preamplifiers (Single Trans.)		349	£4.60
Low-Noise Preamplifier (Dual Trans.)		350	£4.75
Tone Control		351	£4.60
Bandpass Filter		352	£4.75
Frequency Standard Generator – Receiver		353	£4.12
– Digital		354	£6.82
★Biopic Heartbeat Monitor		355	£5.71

PROJECT TITLE		Order Code	Cost
Simple Audio Circuits – 3	**JULY '02**		
– Dual Output Power Supply		356	£4.60
– Crossover/Audio Filter		357	£4.44
Infra-Red Autoswitch		358	£4.91
★EPE StyloPIC		359	£6.50
Rotary Combination Lock – Main Board		360	£5.39
– Interface Board		361	£4.91
★Using the PIC's PCLATH Command – **Software only**		–	–
Big-Ears Buggy	**AUG '02**	362	£5.71
★PIC World Clock		363	£5.39
Simple Audio Circuits–4 – Low Freq. Oscillator		364	£4.44
– Resonance Detector		365	£4.28
Vinyl-To-CD Preamplifier	**SEPT '02**	366	£5.71
★Freebird Glider Control		367	£4.91
★Morse Code Reader		368	£5.23
Headset Communicator	**OCT '02**	369	£4.75
EPE Bounty Treasure Hunter		370	£4.77
★★Digital I.C. Tester		371	£7.14
★PIC-Pocket Battleships – **Software only**		–	–
Transient Tracker	**NOV '02**	372	£4.75
★PICAXE Projects–1: Egg Timer; Dice Machine;			
Quiz Game Monitor (Multiboard)		373	£3.00
★Tuning Fork & Metronome		374	£5.39
★★EPE Hybrid Computer – Main Board } double-		375	£18.87
– Atom Board } sided		376	£11.57
★PICAXE Projects–2: Temperature Sensor;	**DEC '02**		
Voltage Sensor; VU Indicator (Multiboard)		373	£3.00
★Versatile PIC Flasher		377	£5.07
★PICAXE Projects–3: Chaser Lights	**JAN '03**	373	£3.00
6-Channel Mains Interface		381	£5.08
EPE Minder – Transmitter		378	£4.75
– Receiver		379	£5.39
★Wind Speed Monitor		380	£5.08
Tesla Transformer	**FEB '03**	382	£5.07
★Brainibot Buggy		383	£3.00
★Wind Tunnel		384	£6.02
200kHz Function Generator	**MAR '03**	385	£6.34
Wind-Up Torch Mk II		386	£4.75
★Driver Alert		387	£6.35
★Earth Resistivity Logger	**APR '03**	388	£6.02
★Intelligent Garden Lights Controller		389	£3.96
★PIC Tutorial V2 – **Software only**		–	–
Door Chime	**MAY '03**	390	£5.07
Super Motion Sensor		391	£5.55

EPE SOFTWARE

Software programs for *EPE* projects marked with a single asterisk ★ are available on 3·5 inch PC-compatible disks or ***free*** from our Internet site. The following disks are available: **PIC Tutorial** (Mar-May '98); **PIC Tutorial V2** (Apr-June '03); ***EPE* Disk 1** (Apr '95-Dec '98); ***EPE* Disk 2** (1999); ***EPE* Disk 3** (2000); ***EPE* Disk 4** (2001); ***EPE* Disk 5** (2002); ***EPE* Disk 6** (Jan 2003 issue to current cover date – excl. Earth Resistivity); ***EPE* Earth Resistivity Logger** (Apr-May '03); ***EPE* Teach-In 2000; *EPE* Spectrum; *EPE* Interface Disk 1** (October '00 issue to current cover date). ★★The software for these projects is on CD-ROM. The 3·5 inch disks are £3.00 each (UK), the CD-ROMs are £6.95 (UK). Add 50p each for overseas surface mail, and £1 each for airmail. All are available from the *EPE PCB Service*. All files can be downloaded *free* from our Internet FTP site: **ftp://ftp.epemag.wimborne.co.uk.**

EPE PRINTED CIRCUIT BOARD SERVICE

Order Code   Project   Quantity   Price

....

Name ....

Address ....

....

Tel. No. ....

I enclose payment of £................ (cheque/PO in **£ sterling only**) to:

Everyday Practical Electronics

MasterCard, Amex, Diners Club, Visa or Switch

Card No. ....

Card Exp. Date .... Switch Issue No ....

Card Security Code ....
(The last 3 digits on or just under the signature strip)

Signature ....

NOTE: You can also order p.c.b.s by phone, Fax, Email or via our Internet site on a secure server:
http://www.epemag.wimborne.co.uk/shopdoor.htm

EARTH RESISTIVITY LOGGER

JOHN BECKER

Part Two

Help your local archaeological society to locate and reveal the hidden mysteries of our ancestors.

IN Part One last month we discussed the principles of earth resistivity monitoring and described the construction of a circuit through which this could readily be accomplished and the data stored for computer analysis. This month we detail the software that can help in this analysis, and then examine some of the soil probing techniques. The latest updates to the software are then discussed, followed by briefly considering the ethics of surveying and some practical advice and a list of further reading.

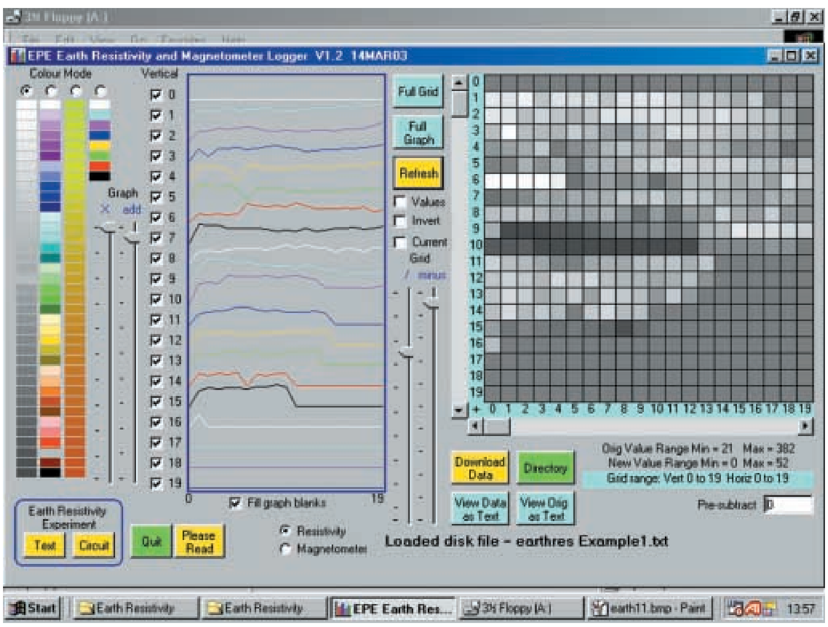
PC SOFTWARE

The Earth Resistivity Logger's PC software is written in Visual Basic 6 (VB6). It has been proved under Windows 95, 98 and ME. It has not been tested with Windows NT, XP or 2000 as the author does not have these systems.

Readers who wish to try running the software under the last three systems may find benefit from reading Mark Jones' article *Running TK3 under Windows XP and 2000*, published in Oct '02.

There are six screens associated with the Logger's VB6 program:

- Main screen as shown below, through which sectional analysis of the survey data is performed
- Full graph screen on which all 128 × 128 download amplitude values are displayed graphically, in oscilloscope fashion (bottom photo on next page)
- Full grid screen on which all 128 × 128 download values are displayed as grid squares having amplitude-related hues or greys (top photo on next page)
- Download screen through which data retrieval from the Logger is initiated
- Directory screen through which previously recorded survey logging files can be loaded for on-screen analysis
- Error Message screen – which hopefully you will never see! This comes into action if the VB6 software detects various types of error (such as trying to load a named file which does not exist). It does not intercept errors which occur outside VB6's specified error interception repertoire as programmed by the author – the PC itself will report any such unlikely events.



Example of the prototype's revised main screen displays and facilities.

MAIN PC SCREEN

The main screen offers several options to enable you to analyse the data received from the Logger. It must be said, though, that the facilities offered through the Windows Excel software supported by most PCs probably exceed what this screen can offer – more on Excel later.

There are two main areas on this screen, as seen in its screen-dump photograph.

To the right is a 20 × 20 grid block of squares, arranged so that the vertical axis represents the survey site columns, and the horizontal axis the site rows. The site data values determine the colour or grey-scale appearance of each of these squares. Two scroll bars are provided which allow the grid data coordinates to be panned vertically and horizontally so that all 16384 values of a 128 × 128 survey grid can be viewed in 400-sample blocks, seamlessly joined.

The range of coordinates from the grid matrix displayed is stated below it. To know the precise coordinate of any square, add the values (numbered 0 to 19) indicated alongside the edges of the matrix.

GRID COLOURING

There is a choice of four options regarding the colour shade range, as shown at the left of the screen. The lefthand bargraph display shows the grey-scale range available, from white to black, 36 shades in all, representing values from 0 (white) to full black (35).

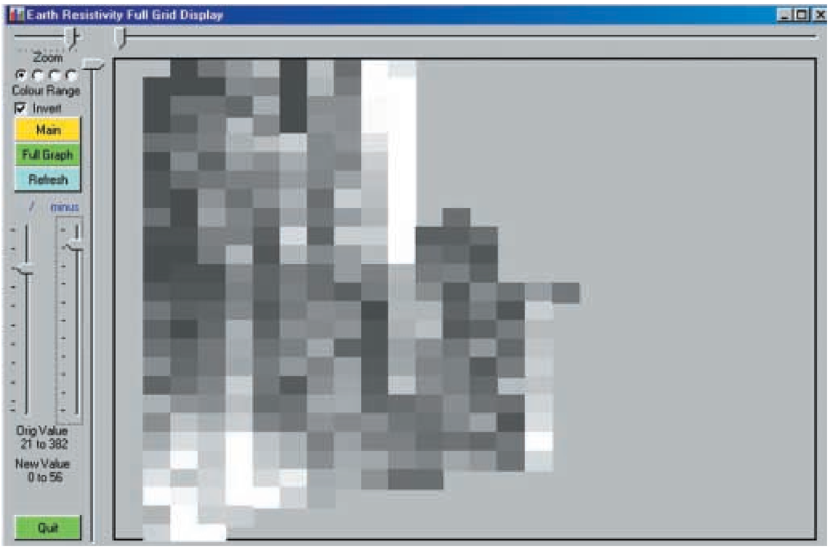
The second bargraph shows a 36-value range of "rainbow" colour shades arranged in the order that VB6 offers them in the system's own (peculiar!) numerical order. They are allocated by the program to represent 0 (top) to 35 (bottom).

Bargraph 3 is a monochrome scale of colours essentially in the green range but with varying intensities of red added. The 36 shades are again numbered from top to bottom as 0 to 35.

The 8-colour bargraph shows the "primary" colours offered by VB6, numbered 0 to 7, top to bottom.

The quality and definition of the scale shades may vary depending on the quality of your VDU.

The scales are selected by clicking on the "radio" buttons above them. In



Example of the full screen grid display, using a zoom value of x9. With zoom at x1 all 16,384 grid squares are shown. The contrast will show more clearly on screen than it may on this printed page.

practice, the greyscale and monochrome bargraph provide the clearest indication of sample value relationships.

The values which are actually obtained from the survey site could, as said previously, fall into the range 0 to 1023. Two slider controls are provided so that the values logged can be suitably displayed as comparative values within the grid squares. They are to the left of the grid squares, jointly captioned Graph, with sub-captions of / (forward slash symbol) and *minus*. Clicking the sub-captions with the mouse cursor toggles them to show *X* (multiply) and *add*, and back again on the next click.

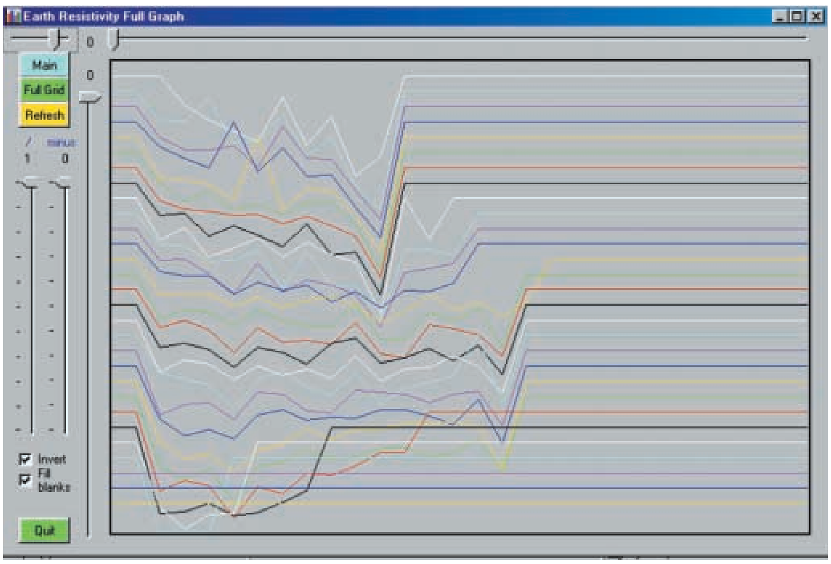
With the lefthand control, moving the slider causes the basic sample values to be either multiplied or divided by the slider's value, according to its sub-caption mode. Similarly with the second slider, adding or subtracting the slider's value. Multiplication/division take place first in the software routine, followed by add/minus.

These two controls allow the optimum shades or colour to be shown that best illustrate the sample value relationships. Even seemingly similar readings can have their values manipulated to increase the contrast.

Above the two sliders is a Show Values tick box. When unticked, just the colour shades are shown. When ticked, the equivalent numerical value of the scale shade, from 0 to 35, or 0 to 7 as appropriate, is displayed within the squares as well. Clicking the box alternates the two modes.

If a particular shade is too dark to read the value, move the mouse cursor over it and a "Tool Tip Text" box will appear, stating the value. Tool Tip Text box messages appear for various functions on screen if you move the cursor over them.

To the bottom of the screen below the grid are two text lines. The first shows the actual range of the sample values, the second shows the range after correction.



Example of the full screen graph display. The zoom is at x9 to emphasise the contour lilnes. The samples cover a maximum area of 16 rows x 26 columns, each sample representing one square metre. The data is the same as in the full grid display and is in eight colours on the screen.

Note that if an original sample value of 0 is found, a dash line (–) is shown in place of a numerical value. This allows recognition of any survey site squares for which a sample has not been taken.

WAVEFORM DISPLAY

The large vertical display area towards the left of the screen shows the sample values plotted as graph waveforms. There are 20 lines (each numbered) representing the numbered grid rows to their right. Horizontally, the lefthand end of each line corresponds with the lefthand side of the grid row.

The two sliders to the left of the graph area allow the plot values to be varied in the same way as with the grid, with the same multiply/divide and add/minus options. Thus the display can again be manipulated to show the survey site features to best degree, in this case as differing amplitude waveforms.

The range of sample graph values is changed at the same time as the grid's coordinate range is set via its scroll and pan sliders.

Below the graph area is another tick box, Fill Graph Blanks. When the box is unticked, any zero values in the original (unmodified) samples are not plotted on screen, indicating any survey site squares that have not been sampled. With the box ticked, the zero values are plotted so that a continuous graph line is shown. Clicking the box alternates the modes.

To the left of the graph display are 20 numbered tick boxes. These allow selected graph lines to be hidden (no tick) to make the viewing of the data in the other lines clearer. As with all tick boxes, clicking them again alternates between on and off.

INVERSION

Below the Show Values tick box is another tick box, Invert Values. When surveying, less-dense soil produces higher values than dense soil. High values produce darker shades on the grid squares and lower troughs on the graph lines.

The Invert Values tick box allows the value relationships to be swapped, high becoming low, low becoming high. This allows denser soil conditions to be displayed more darkly on the grid than for less-dense soil, and the graph lines to show peaks rather than troughs (valleys). Clicking the box alternates between the two modes. The default is for inversion (tick on).

REFRESH BUTTON

The VB6 program allows the main screen to be minimised and shifted in the usual Windows-type fashion. Because VB6 does not regard the graph lines as being "permanent", these can be fully or partially erased by the act of minimising or shifting. To restore the graph lines on-screen, click the Refresh button.

It is also necessary to use the Refresh on the Full Grid and Full Graph screens to action various value selection changes.

FULL DISPLAY SCREENS

There are two buttons, marked Full Grid and Full Graph. They respectively cause the selected full screen mode to be displayed. On both, value manipulation and

inversion are available as on the main screen. So too is colour mode selection.

Above and to the left of the grid and graph areas are two sliders. When clicked, these display the survey site grid coordinates to which their arrows point. Their position is also used by the zoom slider facility at the top left.

There are 10 values of zoom selectable according to the ratio Zoom / 2 + 0·5, with a range of ×1 to ×5·5. The slider arrow positions determine the origin point on which the enlargement is made. Intercepts are included in the program to keep the display within the bounds of its frame.

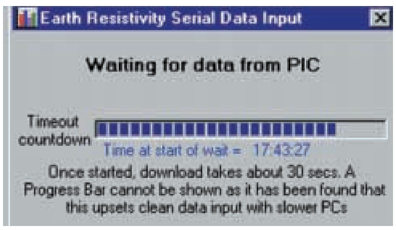
DOWNLOADING DATA

You require a standard serial cable, of the type used with normal modems (D-range 9-way male to female, straight through), for data transfer from the Logger. It should have a connector suited to your PC at one end, and a 9-pin male plug at the other. Adaptors (25-pin to 9-pin) are available if an existing modem lead has a 25-pin male plug.

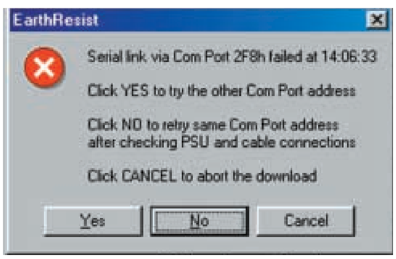
Download option screen.

To download data serially from the Logger, first click on the Download Data button at the bottom of the main screen. This causes a message screen to be displayed, asking if you want to continue with the download, or cancel the call and re-show the full main screen.

If the OK button is clicked the small Download screen is displayed. As advised on the previous message you now have about 30 seconds in which to press the Logger's Download switch S7. During this 30 seconds or so, a bargraph shows the



Countdown bargraph while waiting for data to start coming from PIC.



Screen displayed in the event of data not received due to COM port failure.

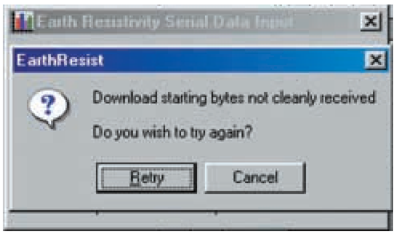
elapsing time before a time-out error occurs.

If the time-out occurs before data is received, you are offered the options to cancel the download, for the PC to try downloading via its other COM port address (there are two allowed for, COM1 and COM2, at addresses 2F8h and 3F8h), or to retry downloading from the same COM port address.

If you choose that the other COM port address should be tried, this address is stored to the EarthResSettings.txt file, which resides in the same folder as the rest of the Earth Resistivity software. It is then recalled next time you run the program.

It is permissible to change the COM port address within this file if you wish (via Windows Notepad for instance) – it is the first entry in the file. Take care not to upset the positions of the other lines in the file. These lines set various parameters for the program each time it is loaded and run.

When the Logger starts to send data before the time-out ends, and the PC begins to receive it, the countdown



Screen displayed if synchronisation is not correct.

bargraph halts and a confirmation that data is being received is displayed. The full 32K block of Logger data (16384 samples) is downloaded at 9600 baud, and initially stored into temporary memory locations.

During this process, another time-out countdown of about one second per data byte is monitored. If this period is exceeded the program assumes that the download is complete (the PIC has stopped sending data), or that the serial link has been broken.

Because the download is asynchronous (i.e. no handshaking), an error checking routine has been included. When the PIC starts transmitting, it first sends several zeros followed by the message RESISTY.

When the PC program finds that the one-second serial time-out has occurred, it checks through the first 20 downloaded bytes to see if these values contain the ASCII coded RESISTY message. It also assesses whether the download quantity is correct.

If neither fact is correct, the screen displays a message box stating so, offering the option to try again or cancel the download.

Occasionally, the PC software thinks that data is arriving immediately following the click of OK in the Download message box, even before the Logger's Download switch S7 has been pressed. The reason has not be found. It is a rare situation, though, and in this event the PC software almost immediately experiences a time-out as data does not continue to arrive, and then offers you the option to try again.

It is worth waiting a couple of seconds after OK has been clicked before pressing switch S7, in case this situation is about to occur. Once the Logger has started to send data the process must run its full course and cannot be halted. The same applies to the PC routine, it too cannot be interrupted, and will continue until a time-out has been experienced.

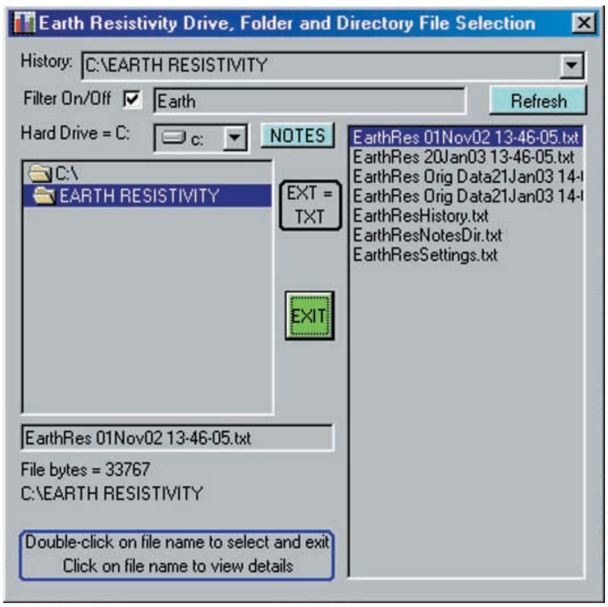
It had been hoped to provide a bargraph to graphically show the progress of the download. Regrettably, it was found that on slower PCs the software is incapable of simultaneously updating the bargraph (or other visual forms of timing) and reliably inputting the serial data. Consequently, this option has not been provided. It takes about 30 seconds to download the full 32768 bytes. A starting time is displayed on screen below the primary time-out bargraph.

When the download has been successfully finished, a routine combines all the double-byte values into single 16-bit binary values. These are converted to decimal and combined into lines of text data, each value separated by a comma. Each line holds the data for one survey site row (128 values). There are 128 lines, representing the number of survey columns.

This data is then output to disk, to a file whose unique name is in the form of the following example:

EarthRes 12JAN03 10-27-35.TXT

in which the date and time (hh-mm-ss) is that applying at the moment that the file is



Example of the folder directory screen through which files from any folder path can be selected according to a filtered prefix option.

created. (The Logger itself has not been provided with date or location recording options – it is up to you to record this information in some other way.) The file is held in the same folder that holds the rest of the Earth Resistivity software.

Having saved the file, the software splits the recombined values into a matrix of registers whose coordinates correspond with those used during the site sampling.

It is these values that are used for display via the main screen's graph and grid areas. They are plotted there immediately the Download screen closes. Simultaneously, the grid matrix location coordinate sliders are reset to zero. The value correction sliders are left as previously set, allowing various sets of file data to be recalled from disk for viewing under the same corrective conditions.

On return to the main screen after the Download, the name of the current file loaded (in this instance that just saved) is displayed in bold towards the screen's bottom right.

LOADING SAVED FILES

To load the program with data from a previously saved file, click on the Directory button. This displays a multi-function screen through which files in any folder on any installed disk can be selected. It is a modified version of the Directory screen originally designed for use with the author's *PIC Toolkit TK3* software (Nov '01), and since used in modified form with other VB6 programs as well.

It will not be discussed in detail here as the screen has a NOTES button which calls up a Windows Notepad text window through which you can read the detail of the Directory screen's use.

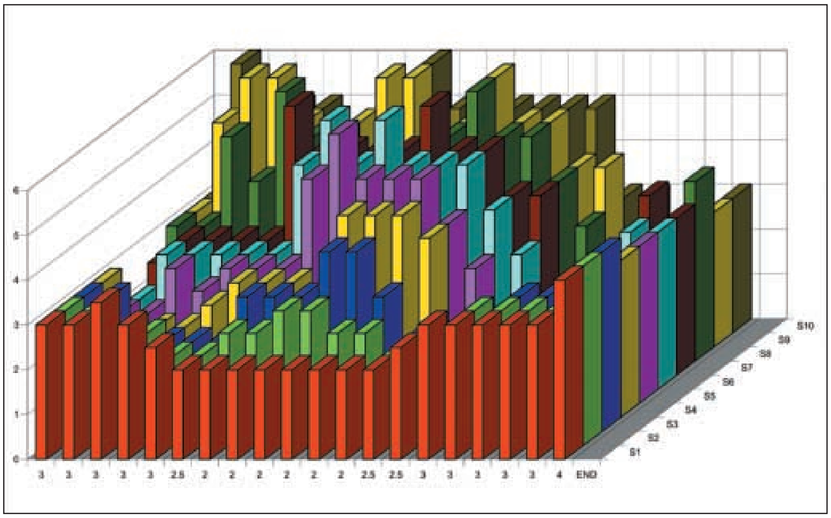
In brief, you can change drives and folder paths, set a "filter" option to only show files having a specified prefix in their name, and recall previously selected paths through a History box. To select a file, double click on its name in the righthand display area. This causes it to be loaded and split for grid matrix allocation in the same way that the downloaded file just discussed was split and displayed.

One of the author's files is included with the software (but with fewer that 400 samples), plus a much longer one produced by Nick during his survey work. Experiment with them and the screen's manipulative controls.

USING WINDOWS EXCEL

When the downloaded survey data is output to disk, it is formatted to suit its analysis and display via Windows Excel, a facility that should be on any PC running Windows 95 and later (search your Windows CD-ROM for it if it is not already on your system).

As well as offering graphing facilities, Excel provides for mathematical expressions to be computed, making it capable of being set-up to calculate true earth resistivity in relation to known resistance and current factors. Study Excel's Help facility, and read Anthony Clark's book. (As said last month, though, Nick's surveys were done in relation to signal amplitude values and not the actual resistance, but see later.)



Example of using Windows Excel to display data graphically.

The formatting simply entails using commas to separate the sample values, which are expressed as normal text characters (e.g. 1234).

Inevitably, there are many versions of Excel and specific use details that apply to all of them cannot be given. The chances are, though, that the use will be similar to that on the author's main PCs. The following is the procedure he uses for Excel 97:

Load Excel, using Windows' Find button to locate it if necessary – on the author's PCs it is at

C:\MSOffice\Excel\EXCEL.EXE

Now follow the path File (in top toolbar), Open, Select folder, set File Type to Text Files, then double click on the required EarthRes file name to load it. A Text Import Wizard – Step 1 of 3 window is now shown, with the first several imported values on display. Select the Delimited option as the active "radio" button.

Click Next to show the Text Import Wizard – Step 2 of 3 window. Click the "Delimited Comma" box to reveal a tick. Click other ticks to become unticked (if necessary). Ignore the "Text Qualifier" box.

Click Next to show the Text Import Wizard – Step 3 of 3 window. Ignore the options offered, but click Finish.

The main Excel screen will now be shown, with the survey values allocated to column and row boxes.

Left click on one of these boxes, say the first one at top left, to select the starting coordinate of the matrix area you wish to show graphically. With the left mouse button still held down, move the mouse downwards and to the right, causing the selected boxes to show white text on a black background as the area is increased. The first box, though, remains as black on white.

EXCEL GRAPHING

Release the mouse button when you've selected the required area. Now click on the Chart Wizard icon on the top tool bar (it looks like several vertical rectangles, with an elongated diagonal shape above them – a chimney falling onto a factory?). The mouse cursor becomes a similar (but not identical) symbol plus a cross, representing that graphing mode has been selected.

Move this cursor anywhere over the darkened area and left click to reveal the Chart Wizard – Step 1 of 5 window. The darkened area reverts to normal black on white, surrounded by a dotted box, possibly "shimmering".

Ignore the options offered and just click Next, to show the Chart Wizard – Step 2 of 5 window. Select (left click) one of the graph type options offered, the "3-D Column" option is suggested.

Click Next to show the Chart Wizard – Step 3 of 5 window. Select one of the chart type variants on offer, the one numbered 6, perhaps.

Click Next to show the Chart Wizard – Step 4 of 5 window, and an illustration of the Sample Chart selected will be seen. Ignore the right hand option boxes and click Next, to show the Chart Wizard – Step 5 of 5 window. Now just click on Finish.

The graph type selected will now be displayed on the main Excel screen, with the value boxes still visible behind it. It can be moved around the screen and sized in the usual Windows style. A small (mobile) Chart selection window will also be displayed, allowing different options of display to be selected and manipulated.

Save the file and its graphical displays (more than one can be generated on the screen at any time and placed at different positions) as an Excel-type file with any name of your choosing. Alternatively, simply Exit unsaved if you prefer.

It is now up to you to experiment with Excel's numerous options, calling up its Help files for more information. It is an amazing package with many uses, and seemingly ideal for the sort of analysis that archaeological survey data calls for. In a word – experiment!

PROBING METHODS

The construction of the probe assemblies will be discussed once some of the probing techniques have been examined.

There are several probing methods available through which to obtain grid data about a survey site. The author makes no attempt to recommend any one in particular. You must do your own research into that, through the references given later, and by chatting to those in archaeological societies who know about such things.

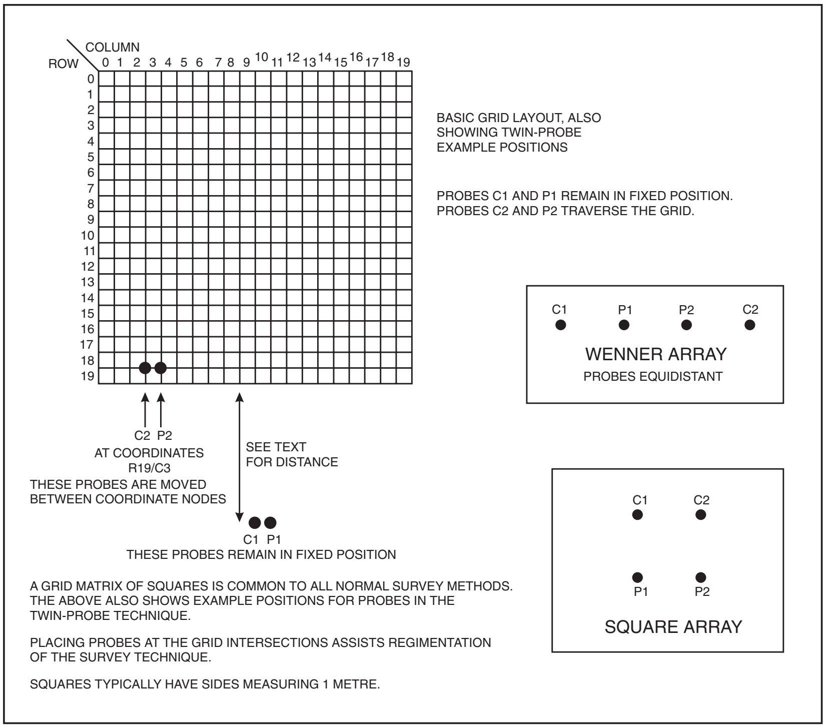


Fig.8. A 20 x 20 grid layout with Twin-Probe example positions, and the positioning of the probes in Wenner and Square arrays.

There are numerous archaeological web sites with bulletin boards and "chat-zones" on-line if you search through the excellent **www.google.com**, or other quality internet search engines. It is worth noting, though, that Anthony Clark considers the Twin-Probe technique to be that most suitable to archaeological work, and is the one used by Nick with his surveys.

With all techniques, the area to be surveyed is first marked out as a grid with tapes or similar, to form squares having sides of, say, one metre in length (this is a commonly quoted distance in this context), and probably forming a 20 × 20 matrixed area, see Fig.8.

Anthony Clark comments that plastic covered clothes line is also useful for setting out a grid matrix. He cautions, though, that it can be difficult to untangle and on one site he knows of, it had to be "guarded in the presence of sheep, by whom it was regarded as a rare delicacy"!

TWIN-PROBE

The Twin-Probe technique is apparently more suited to initial surveying of a site, establishing whether or not it is worth carrying out a more detailed survey.

With this method, the two probes C1 and P1 are inserted into the ground, sufficient to make electrical contact with it (see earlier), centrally to and somewhat outside the area to be surveyed. Anthony Clark discusses the best distance in his book.

Probe C1 is the transmitting probe connected to the comparator IC3, via switch S2. Probe P1 is one of the receiving probes, connected to the input of op.amp IC4a.

Probes C2 and P2 are inserted into the ground, to a similar depth, at the far corners of the first square to be monitored, say top left, coordinate R0/C0 (row 0, column 0). Probe C2 is the 0V reference probe, and P2 is connected to the input of op.amp IC4b. The respective leads from the Logger are then connected to the probes, using heavy duty crocodile clips seems the easiest method.

The Logger's storage coordinates are set to suit the square number, i.e. to R0/C0 in this case, and a reading saved to the Logger's serial EEPROM by pressing switch S8.

The C2/P2 probes are then moved to the top corners of the next square, to the right for example, to be monitored and its coordinates set into the Logger, in this case R0/C1. Again a reading is stored to the EEPROM.

The process continues fully across horizontally for the width of the marked survey area, e.g. R0/C19 (the final column of this row in a 20 × 20 grid). The probes are then moved down by one row, and the process repeated, to the left this time, back to R1/C0. And then down by another row, and so on for all 400 squares.

WELL ORDERED

Note that the relative order of all probe connections must be maintained during the survey. Differences in reading can result if the order is changed, hence the earlier recommendation that the plugs and crocodile clips should be colour-coded.

In practice, it does not matter in which direction you move the probes, or whether you start the survey from the top of the grid or the bottom. Note that the PC screen regards location 0,0 as being at top left of the screen.

"Be methodical and consistent" seems to be the key phrase, though – this helps you to establish a routine that becomes second nature, which the author soon found when starting his own mini surveys!

It was also soon found that it is not necessary to move both probes on each occasion. Since one is already at the corner of the next square, it is only necessary to move the probe from the corner now finished with, putting it in the next square's opposite top corner, and swap the probe leads to retain the correct order.

The author surveyed his garden several times in different ways during design development, and on each occasion became faster at doing so. On the final survey, on an 11 × 7 grid (77 samples) it took about an hour and half.

Of course, during the process of doing the test surveys, several methods for speeding it were imagined. For a solitary surveyor, perhaps the most efficient in terms of speed would be to insert separate probes at each corner of the matrix prior to taking readings. It would then only be required to repeatedly change the lead connections – a seemingly much faster "conveyor belt" system. No doubt, though, having an assistant would probably make the moving of just two probes a speedy alternative.

A perhaps less practical method was (bizarrely?) thought up too – using a motorised vehicle like a golf buggy with probes attached to the wheels in Boadicea fashion. This would then be driven back and forth across the grid, the probes automatically inserting themselves, and triggering the storing of each reading at the correct coordinates! (Well – a chap can dream, can't he?!)

WENNER PROBING

Another seemingly useful technique is known as the Wenner configuration. In this method the four probes are arranged in a straight line, equally spaced apart, say a metre between them. Fig.8b shows the order of arrangement.

This method is apparently better suited to doing a more detailed survey of the matrixed grid site. The principle is that the TX probes are the outer two. The RX probes are in line between them. The current flows across the TX pair and is picked up across the RX pair, the received signal value varying with the resistance in series with the probes in a more direct fashion than with the twin-probe technique.

A variant of this technique, the Schlumberger, in which the probes are not equally spaced, is discussed in Anthony Clark's book. But he regards it as not ideally suited to archaeological surveying.

SQUARE ARRAY

Another method is known as the Square Array in Anthony Clark's book. With this method, the TX and RX pairs are placed at the corners of the one metre squares, as shown in Fig.8c. The four probes are moved as a set from square to square.

The transmission signal flows between the TX pair as before. This time the RX pair pick up the radiated signal at the same distance from the TX probes. If the soil resistance between the TX and RX pairs is uniform, so too will be the amplitude of the signal received by both RX probes.

Tests showed that because the probes are connected to a differential amplifier, if the two input amplitudes are the same, they will cancel each other out at the final combining stage (IC4c).

If, on the other hand, the amplitudes are not the same, the difference between them is that which will be finally output from IC4c. In this case, what would be looked for is any difference values, indicating the edge of a subterranean feature.

It is evident, however, that balanced (zero) readings, when the two input values are equal, would only indicate the uniformity of the terrain in that grid. It would not indicate whether that uniformity was due to a highly resistive feature or a highly conductive one. Nonetheless, the detection of only outlines might in itself be a desirable situation.

A variant of this technique would be to place the two TX probes at one end of a column, and the RX pair at the other, taking a reading and moving both pairs to the next column, still at the top and bottom points. This could perhaps yield initial information about whether or not a site is worth examining more closely. Not being an archaeologist, though, the author cannot comment on the validity of this.

Anthony Clark discusses the above named probing techniques in more detail, and describes others.

PROBE CONSTRUCTION

During garden tests with the prototype Logger, individual metal rods measuring about one metre long by 5mm diameter, and with a right-angled bend at the top were used as the probes. These were purchased inexpensively from a garden centre, their intended use being to support plants.

A recently observed, but not tried, possibility was in the form of long inexpensive barbecue skewers – seen in a local supermarket.

If you wish to construct purpose-built probe structures of more durability, and perhaps greater ease of use, the probe assemblies described by Robert Beck should be considered. Schematics of the original figures illustrating these probes have been redrawn and are repeated here. Other than the following details, no additional information can be offered.

Robert's rigid frame assembly for two probes is shown in Fig.9. Details of his single probe are given in Fig.10.

His original text states that the Twin-Probe assembly was specially developed and that its top member is a wooden batten, 30mm × 50mm × 1050mm, the ends of which are bound with self-amalgamating tape to form hand grips.

An aluminium platform is attached to the centre of this batten to carry the case that holds the electronics, secured by rubber bands. The bottom member is a similar wooden batten, but this piece must have good insulating properties (to prevent current leakage between the probes). He suggests that you either dry and coat the batten with varnish, or devise insulating collars of Tuffnol or similar material, and fit them where the probes go through the batten.

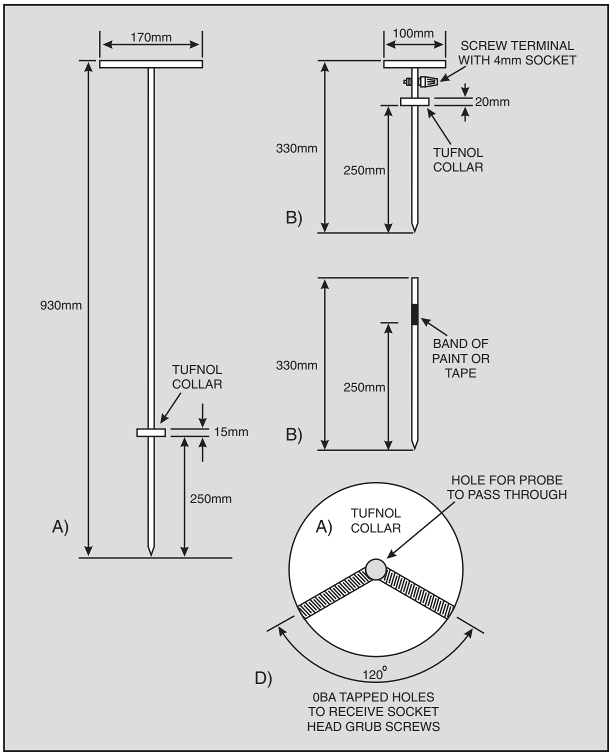


Fig.10. Construction details of Robert Beck's probes.

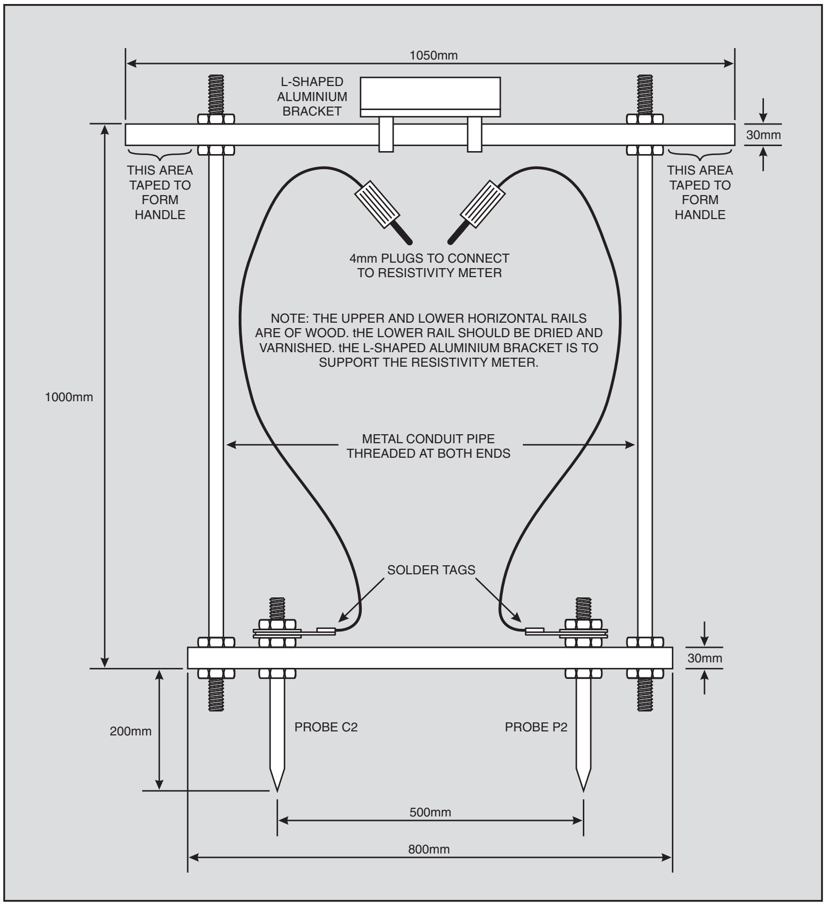


Fig.9. Support frame for the Twin Probe configuration used by Robert Beck.

The top and bottom battens are held together by metal conduit pipes, threaded at each end and secured by lock-nuts.

In describing the construction of the other probes, he says that none of their dimensions are critical and may be dictated by what is to hand. In Fig.10a is shown a substantial probe made out of stainless steel tubing with a brazed on T-handle and tip which assist soil penetration. This probe is designed to be used by the operator in the standing position.

A smaller version of Fig.10a is shown in Fig.10b. This has a 4mm screw terminal added, an alternative method of wire connection.

Probes may be constructed of material other than stainless steel, which is expensive and a little difficult to obtain, he says (provided it is corrosion resistant of course).

An extremely simple probe is shown in Fig.10c and which may be constructed from 6mm diameter metal rod, i.e. brazing or uncoated welding rod, mild steel, silver steel, etc. A depth guide consisting of a band of paint or insulating tape is added and connections are made to the top using a crocodile clip.

The depth stop in Fig.10d is adjustable by means of an Allen key. The material need not be insulating, and could be of metal if desired.

SERIAL OCX

Since finalising the *Earth Resistivity Logger* Part One for publication last month, reader Joe Farr has provided *EPE* with a specially written SerialIO.OCX program that allows legal access to Visual Basic's own serial control I/O facilities.

This option has previously only been available to readers who have a registered version of MSCOMM (as Robert Penfold has discussed many times through his *Interface* series).

Joe's serial OCX facility will be published in full at a later date – probably the September issue. However, a section of Joe's program has been built into this Earth Resistivity (ER) program and is available to readers who are using the EarthResist.EXE standalone version.

To use Joe's option, though, several changes need to be made to ER's p.c.b., without which the facility cannot function. They are:

1. Cut the track (0V) connecting to IC7 (MAX232) pin 13.

2. Connect IC7 (MAX232) pin 13 to 9-pin serial socket SK3 pin 3.

3. Connect IC7 (MAX232) pin 12 to IC5 (PIC) pin 18 (RC7).

This action allows the PIC to receive handshake data from the PC.

To set the PIC program to respond to the correct serial data transmission routine, initiate the following procedure:

1. Before switching on power, press and hold down the Mode switch, S6.

2. The screen will go into serial path change mode, alternating at about one-second intervals between a display saying "SERIAL PORT NORM" (original version) and "SERIAL PORT OCX " (Joe's OCX).

3. Release switch S6 when the mode you require is shown. This mode becomes the active path mode and is also stored into the PIC's data EEPROM, to be recalled next time the program is run.

4. On release of switch S6, normal running of the PIC program resumes. The serial path mode may be changed whenever you choose.

PC OCX SETTING

Ensure that the PC is also set for the chosen mode, as follows:

Click the on-screen button labelled Please Read. Accept the option that then follows to read the text. Having read it, exit the text reading screen to reveal another options screen. This allows you to choose between the new OCX option and the original (normal) serial mode. Click YES for Joe's OCX, NO if you want to use the normal serial download as originally written into the ER program, or CANCEL to exit without making a change to the serial path used.

Your choice is recorded to disk and recalled next time the program is run. You may change your mind at another time if you wish, re-entering via the Special Note button to do so.

Note that the same mode **must** be selected for the PIC and the PC.

The advantage of Joe's program is that it allows a bargraph to display the progress of the data input procedure. It is also likely to be better at detecting input data problems as it uses a handshake procedure to communicate with the PIC, inputting the 32768 bytes of data in blocks of 256 bytes.

Whilst the original program inputs data that is usually 100% accurate, there is the occasional loss of synchronisation, which is reported on screen, allowing you to re-download if you prefer, although minor "first aid" is provided by the program to regain sync after that point. It is rare, though, for more than one loss of sync to occur. Such loss should not occur with Joe's OCX program.

It should be noted that readers who wish to make their own changes to the ER source code cannot make use of Joe's OCX input option. For that to be used, the installation of Joe's full OCX facility is required. For copyright reasons this will not become available to readers until its publication. Attempting to examine the ER source code will generate an error condition because of the presence of Joe's program. Until Joe's full serial program becomes available, the ER program can only be recompiled if Joe's sub-program (EarthResOCX) and all references to it in the main program are removed.

Also be aware that this version of ER with Joe's OCX has not yet been proved on a wide variety machines. If it will not work on your PC, revert to using the normal serial download option on PIC and PC. Please advise us at HQ if this is necessary, telling us the PC and its operating system type.

SURVEY CURRENT MONITORING

Another feature added to this version is the ability to monitor the current flowing between the transmission (TX) probes. It too requires a small change to the PCB:

1. Cut the track between resistor R16 and pin 7 of IC4.

2. Connect the now-open end of R16 to the pole of switch S2.

With switch S2 in the R5 (1k resistor) position, current flows from the switch pole through the 1k resistor and to 0V via the resistance of the soil. These two resistances form a potential divider. The square wave voltage at their junction is buffered by R16 and half-wave rectified by diode D2. The resulting peak positive voltage is monitored via PIC pin RA0 operating in analogue (ADC mode). The peak voltage depends on the resistance of the soil, and from this voltage value the equivalent relative current through the resistance path can be calculated.

To establish an initial reference value prior to any survey, switch on the unit. Then set switch S2 to the setting that directly connects the pole to IC3 output pin 6. Do not connect transmission probe C1 to socket SK2 at this time. Press switch S6 (Mode) and hold it pressed, then press switch S8 (Save) and hold it pressed until the message REF SAVED appears, preceded by a value. Release S8, then release S6. The value shown is now stored to the PIC's EEPROM for present and future use. Then switch S2 to the 1k resistor (R5) path.

During active surveying, the voltage at the pole of S2 is subtracted from the reference value and stored as a 6-bit number into bits 1 to 6 of the MSB of the survey value recorded to the external serial EEPROM IC6. The range of current values acceptable is from 0 to 63, and the actual value is displayed as the second value on l.c.d. line 1 when in Test Mode (S9 on). It is followed by the letter A. The first value shown (followed by B) is that monitored from IC4b pin 8, as described in Part One. The output from IC4a is no longer monitored via the l.c.d.

If current values greater than 62 are encountered, they are limited to 63, and the word MAX is displayed on the l.c.d. Switch S2 may be used to select one of the other resistors (R3 to R6) in the event that the site being surveyed has greater or lesser resistance than appropriate to a 1k fixed resistor value. Do not change the resistor value during a survey.

The PC program stores the full 2-byte survey value to disk. On re-input the current value is extracted from the MSB, and the MSB is then limited to one active bit (bit 0). The range of survey values is then from 0 to 511. During surveying, the gain setting via switch S3 should be chosen to keep the values below 511, favouring a middle range centred on 256. If a value greater than 511 is encountered by the PIC, it is limited to 511 and the word MAX is shown on the l.c.d.

CURRENT ON/OFF OPTION

All three display screens of the PC program now have an extra tick box marked Current. When it is ticked, each survey value is multiplied by its associated current value divided by 10. The theory is that slight differences in the transmission current value at each survey grid square affect the actual value of the received voltage signal from the receiving probes. By relating these voltages to their prevailing transmission current, compensation is made for variations in the latter. The current values are not actual milliamp values, but simply numbers representing the relative current flowing.

It is suspected, however, that in practice the variations make little difference to the interpretation of the displayed results. To repeat the statement made in Part One, the aim of this Logger is to show relative differences in signal amplitude across a site being surveyed. It is the differences that then indicate different sub-soil features.

If there are significant differences they are worth physical investigation. If there are no significant differences, then the site is probably not worth examining further, unless such techniques as magnetometry or ground-penetrating radar reveal differently. A magnetometer design is currently being worked on and will be published in *EPE* at some time in the future, but not yet scheduled.

We shall be interested to learn if you find that the current-monitoring feature enhances the results of your survey. Let us know via EPE HQ.

DOT MATRIX

A further option added to the PC program since Part One is the dot-matrix display facility, operative when the Matrix tick-box on the Full Grid screen is ticked. This draws small squares on the display whose dimensions are relative to the signal amplitude.

The principle is a bit like the dots that make up a B&W photograph in a newspaper (known as half-tone). It will be more useful with a large amount of survey data on screen than with a small quantity.

MISCELLANY

A few other "tweaks" have also been added since Part One.

The text and demo circuit for some experiments referred to on Part One page 1 are now accessible via buttons at the bottom left of the screen.

Two other buttons allow you to examine the survey data as text files, one showing the twin-byte values separately, the other as the full combined value. These values include the current values as well.

All three display screens have also been given a "pre-subtract" box, allowing you to subtract, say, the minimum value received from all other values, enabling relevant data to be extracted from any overall bias levels.

Because this PC software will be used with the Magnetometer currently under development, two "radio" buttons allow selection of whether Earth Resistivity or Magnetometer data will be processed. Ensure that the Resistivity button is the one selected.

ETHICS

It was said in the opening paragraph in Part One that the original *Earth Resistivity Meter* published in *EPE* was an electronic tool to assist amateur archaeological societies. So too is this Logger design.

Whilst there is nothing to stop anyone from carrying out surveys on their own property, there are considerable ethical issues regarding the surveying of other land.

First, other land is not *your* land, and so any surveying of it requires the permission of those who own it. Remember that **all land in the British Isles is owned by someone**. Find out who it is and gain their permission before you proceed.

Secondly, **do not dig without an archaeologist's involvement**. If you have located through your earth resistivity survey something that proves to be a site of any importance, your unsupervised digging will certainly destroy information that is necessary to fully interpret the site.

Earth resistivity surveying is essentially non-invasive except for the slight intrusion made by the probes just into the surface. Many landowners could well be as interested as an archaeological society in knowing what history might lie beneath their land, especially if they are approached in a polite manner and it is explained to them that the resistivity surveying is just a matter of sticking some shallow probes in the soil.

Remember that some locations are designated as Scheduled Ancient Monuments and that permission to carry out any form of research on them requires official approval. Experienced local archaeological societies will know where these sites are and whether or not surveying permission is likely to be granted, and if so, by whom. If such information is not already known to a society, enquiries at the local town hall should provide answers.

JOIN A SOCIETY

It really is in your interests to join an archaeological society if you are not already a member. It is also in the society's interests if you join them and they then have the use of your Logger!

Nick's survey was done not far from where John Constable painted this Boat Building Near Flatford Mill *scene. The contours in the full graph screen shown earlier clearly indicate a trench comparable to that in this painting.* Illustration courtesy of www.excelsiordirect.com/constable.htm.

To find a local society, look in the telephone directory, or ask at the library. The author's local library building even has a display of the artefacts found by the society in his area. It is a region once heavily populated by the Romans, with many artifacts that have been found on display, and even the ruins of two Roman villas (but left where they were found!).

Only a few hundred yards from the author's house a Roman corn drier was recently found by his local society. 400 yards further on are the ruins of a Roman bath house. It is quite probable that his garden is on a site where Roman's once trod.

Although his survey graphics did not show anything other than known modern features, and probably including builder's rubble of recent decades, perhaps he'll one day do a more detailed survey and then call in the archaeologists to uncover an amazing find – one way to get the garden dug for him!

NICK'S SURVEY

Nick was fortunate enough to be permitted to survey a site made famous by English artist Constable (before he was promoted to Sergeant says reader and friend John Waller – quoting an old Goon Show line!).

Constable painted several pictures of sites at and around Flatford Mill in Essex. One of them is his *Boat Building Near Flatford Mill*, which is reproduced here. It is near that site that Nick surveyed and his results are those illustrated earlier in the full graph and full screen illustrations. They reveal very clearly the sub-surface features that could have been bays cut into the ground where boats might well have been tied up. Much of the site, though, is now overgrown with trees, preventing adequate survey.

The primary area covered in the survey is approximately 16m × 26m at maximum dimensions. Most of it was covered in one day, but then rain "stopped play" for several weeks.

PRACTICAL ADVICE

From his experience with the prototype of this Logger, and from his general surveying activity, Nick offers the following advice:

- For extensive survey work the battery needs to be bigger than PP3 size
- The case should be larger than in the prototype and a better shape to carry about
- Do not use small plugs and sockets
- The sockets need to be solidly mounted, possibly on a metal base of some description, and include strain relief, it's surprising how hard you have to pull 50m of cable laying on wet grass!
- Lay the survey out accurately, based on a 3, 4, 5 triangle to get the lines perpendicular. Bamboo canes make good markers for the 1-metre grid intersections. If using clothes line with metre marks, beware that rope stretches. Survey tapes (typically 30m) need to be carefully cleaned after use, or they get full of dirt and can jam
- Keep perfect track of what you have surveyed, it is horribly easy to lose track of the grid section that you have just recorded
- Probe around the site at random before you start to make sure that you are set up to keep the Logger's values roughly around 250
- Try and get it all done in a day – a shower overnight throws in a step function because you are then working in the area that the rain will have penetrated
- Coil everything neatly – controlling 50 metres of cable across a plot is tricky

- Buy high visibility cable in case someone tries to trip over it!
- Colour code the probes – you need to be consistent
- Ask permission, most people will be chuffed to bits that you want to do the survey – but not everybody, and make sure that you are not somewhere where you should not be
- Make contact with your local archeology group, they will be very helpful and interested, and may well bite your arm off to get you helping them
- Be prepared to talk to people, you will cause interest if you are somewhere public, and they will be surprisingly knowledgeable – and probably have all been watching *Time Team*
- Keep your ears open for local stories of old ruins, you might be the one that rediscovers something lost to history because you happened to take the time to listen to the ramblings of the old guy in the pub
- You can do a survey on your own, but it is much easier with two of you
- Keep a note book that notes the time, place, date, etc of the survey and things like weather conditions which could explain odd results, for example if it started to rain half way through the work
- Any survey must have a repeatable base point, or base line so that if you do find something interesting, you can be sure where it was without having to repeat the survey!
- Use compass bearings, fixed physical features, corners of buildings, drain covers etc, or triangulate from fixed points if the survey is in an open area. Most archaeologists work north to south.

ACKNOWLEDGEMENTS

The author offers very grateful and appreciative thanks to Nick Tile for carrying out extensive field tests with the prototype, for discussing at length many aspects of its use, for lending *Seeing Beneath the Soil* and vetting the script.

The author also thanks those *EPE* readers who provided him with information during the development of this design (in alphabetical order!):

Dave Allen for sending an ancient issue of *ETI* containing a rudimentary ER circuit using d.c. probing (and yes Dave, this design could be used for monitoring relative impurity content levels in water).

Peter Barnes, for vetting the script and for several useful email exchanges of thoughts and circuits, plus comments from his archaeologist acquaintance Derek about using Robert Beck's design.

Robert Beck, for the original inspiration.

Aubrey Scoon, for comments about stray electrical currents in the soil.

ODAS, the Orpington and District Archaeological Society, and Alan Hart in particular.

FURTHER READING

Applied Geophysics, W.M. Telford, L.P. Geldart, K.E. Sheriff, D.A. Keys. Cambridge University Press. ISBN 0521-20670-7.

Applied Geophysics, Griffiths and King, Pergamon Press. 1965. (ISBN unknown).

Seeing Beneath the Soil, Prospecting Methods in Archaeology. Anthony Clark. Routledge. 2000. ISBN 0-415-21440-8.

This is a revised edition of the title referenced in *EPE* Feb '97, and having a different ISBN and publisher. It is the most informative source used by the author during the design of this Logger.

It additionally covers other earth surveying techniques, including magnetometry, and provides several further reference sources. It is known to be available for on-line ordering from **www.Amazon.com** and **www.BOL.com**, current price around £25.

USEFUL WEB SITES

www.archaeology.co.uk. Various aspects of the subject, including further links, access to the magazine *Current Archaeology*, and to the Council for Independent Archaeology.

www.geop.ubc.ca. Source of semi-mathematical tutorial on earth resistivity and a link to a site called Introduction to Exploration Geophysics.

www.google.com. Excellent search engine.

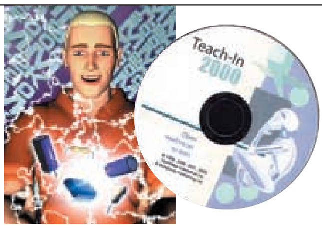
LOGGING OFF

The ER software placed on the *EPE* ftp site on 17 March '03, was version V1.2. Look in on the site occasionally to see if any further updates have been introduced. □

CORRECTION

Crystal X1 should be 3·6864MHz (as in Fig.5), *not* 3·2768MHz as in the components list.

FREE *Electronics Hobbyist Compendium* book with Teach-In 2000 CD-ROM



EPE TEACH-IN 2000 CD-ROM

The whole of the 12-part *Teach-In 2000* series by John Becker (published in *EPE* Nov '99 to Oct 2000) is now available on CD-ROM in PDF form. Plus the *Teach-In 2000* interactive software covering all aspects of the series and Alan Winstanley's *Basic Soldering Guide* (including illustrations and Desoldering).

Teach-In 2000 covers all the basic principles of electronics from Ohm's Law to Displays, including Op.Amps, Logic Gates etc. Each part has its own section on the interactive software where you can also change component values in the various on-screen demonstration circuits.

The series gives a hands-on approach to electronics with numerous breadboard circuits to try out, plus a simple computer interface which allows a PC to be used as a basic oscilloscope.

ONLY **£12.45** including VAT and p&p

Order code Teach-In CD-ROM

DIRECT BOOK SERVICE

The books listed have been selected by *Everyday Practical Electronics* editorial staff as being of special interest to everyone involved in electronics and computing. They are supplied by mail order direct to your door. Full ordering details are given on the last book page.

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF EPE.

All prices include UK postage

PROJECT CONSTRUCTION

PRACTICAL REMOTE CONTROL PROJECTS
Owen Bishop

Provides a wealth of circuits and circuit modules for use in remote control systems of all kinds; ultrasonic, infra-red, optical fibre, cable and radio. There are instructions for building fourteen novel and practical remote control projects. But this is not all, as each of these projects provides a model for building dozens of other related circuits by simply modifying parts of the design slightly to suit your own requirements. This book tells you how.

Also included are techniques for connecting a PC to a remote control system, the use of a microcontroller in remote control, as exemplified by the BASIC Stamp, and the application of ready-made type-approved 418MHz radio transmitter and receiver modules to remote control systems.

160 pages **Order code BP413** **£6.49**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Temporarily out of print**

A PRACTICAL INTRODUCTION TO SURFACE MOUNT DEVICES
Bill Mooney

This book takes you from the simplest possible starting point to a high level of competence in handworking with surface mount devices (SMD's). The wider subject of SM technology is also introduced, so giving a feeling for its depth and fascination.

Subjects such as p.c.b. design, chip control, soldering techniques and specialist tools for SM are fully explained and developed as the book progresses. Some useful constructional projects are also included.

Whilst the book is mainly intended as an introduction it is also an invaluable reference book, and the browser should find it engrossing.

120 pages **Order code BP411** **£5.49**

FAULT-FINDING ELECTRONIC PROJECTS
R. A. Penfold

Starting with mechanical faults such as dry joints, short-circuits etc, coverage includes linear circuits, using a meter to make voltage checks, signal tracing techniques and fault finding on logic circuits. The final chapter covers ways of testing a wide range of electronic components, such as resistors, capacitors, operational amplifiers, diodes, transistors, SCRs and triacs, with the aid of only a limited amount of test equipment.

The construction and use of a Tristate Continuity Tester, a Signal Tracer, a Logic Probe and a CMOS Tester are also included.

136 pages **Order code BP391** **£5.49**

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.

104 pages **Order code BP248** **£4.49**

ROBOTICS

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

Shows the reader how to build a variety of increasingly sophisticated computer controlled robots using the brilliant Lego Mindstorms Robotic Invention System (RIS). Initially covers fundamental building techniques and mechanics needed to construct strong and efficient robots using the various "click-together" components supplied in the basic RIS kit. Explains in simple terms how the "brain" of the robot may be programmed on screen using a PC and "zapped" to the robot over an infra-red link. Also, shows how a more sophisticated Windows programming language such as Visual BASIC may be used to control the robots.

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Covers the Vision Command System

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using Lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

298 pages **Order code BP902** **£14.99**

RADIO / TV VIDEO

ELECTRONIC PROJECTS FOR VIDEO ENTHUSIASTS
R. A. Penfold

This book provides a number of practical designs for video accessories that will help you get the best results from your camcorder and VCR. All the projects use inexpensive components that are readily available, and they are easy to construct. Full construction details are provided, including stripboard layouts and wiring diagrams. Where appropriate, simple setting up procedures are described in detail; no test equipment is needed.

The projects covered in this book include: Four channel audio mixer, Four channel stereo mixer, Dynamic noise limiter (DNL), Automatic audio fader, Video faders, Video wipers, Video crispener, Mains power supply unit.

109 pages **Order code BP356** **£5.45**

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

An essential addition to the library of all those taking their first steps in amateur radio.

86 pages **Order code BP300** **£4.45**

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc. These materials are, in general, cheap to obtain and easily worked with simple tools, encouraging the trial-and-error philosophy which leads to innovation and discovery.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages **Order code BP278** **£4.00**

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave-listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers. Much information is also given on shortwave bands, aerial directivity, time zones, dimensions etc.

50 pages **Order code BP136** **£2.25**

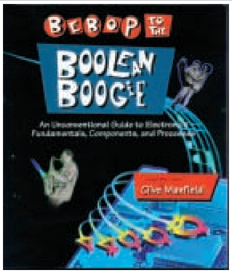
THEORY AND REFERENCE

Bebop To The Boolean Boogie

By Clive (call me Max) Maxfield

Specially imported by *EPE – Excellent value*

An Unconventional Guide to Electronics Fundamentals, Components and Processes



This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more (including a recipe for a truly great seafood gumbo!). Hundreds of carefully drawn illustrations clearly show the important points of each topic. The author's tongue-in-cheek British humor makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. A great reference for your own shelf, and also an ideal gift for a friend or family member who wants to understand what it is you do all day. . . .

470 pgs – large format **Order code BEB1** **£26.95**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

This follow-on to *Bebop to the Boolean Boogie* is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. If you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

Over 800 pages in Adobe Acrobat format
£21.95 including VAT and p&p

Order code BEB2 CD-ROM

ELECTRONICS MADE SIMPLE
Ian Sinclair

Assuming no prior knowledge, *Electronics Made Simple* presents an outline of modern electronics with an emphasis on understanding how systems work rather than on details of circuit diagrams and calculations. It is ideal for students on a range of courses in electronics, including GCSE, C&G and GNVQ, and for students of other subjects who will be using electronic instruments and methods.

Contents: waves and pulses, passive components, active components and ICs, linear circuits, block and circuit diagrams, how radio works, disc and tape recording, elements of TV and radar, digital signals, gating and logic circuits, counting and correcting, microprocessors, calculators and computers, miscellaneous systems.

199 pages **Order code NE23** **£13.99**

SCROGGIE'S FOUNDATIONS OF WIRELESS AND ELECTRONICS – ELEVENTH EDITION
S. W. Amos and Roger Amos

Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.

400 pages **Order code NE27** **£21.99**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£4.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. SInclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

MUSIC, AUDIO AND VIDEO

QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

Even though music production has moved into the digital domain, modern synthesisers invariably use analogue synthesis techniques. The reason is simple – analogue synthesis is flexible and versatile, and it's relatively easy for us to understand. The basics are the same for all analogue synths, and you'll quickly be able to adapt the principles to any instrument, to edit existing sounds and create exciting new ones. This book describes: How analogue synthesis works; The essential modules every synthesiser has; The three steps to synthesis; How to create phat bass sounds; How to generate filter sweeps; Advanced synth modules; How to create simple and complex synth patches; Where to find soft synths on the Web.

If you want to take your synthesiser – of the hardware or software variety – past the presets, and program your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

60 pages **Order code PC118** **£7.45**

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

ALL PRICES INCLUDE UK POST AND PACKING
CD-ROM prices include VAT and/or postage to anywhere in the world

ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

124 pages **Order code PC116** **£10.95**

THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of its detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first elecronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H25' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

420 pages **Order code NE32** **£17.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£10.95**

PC MUSIC – THE EASY GUIDE
Robin Vincent

How do I make music on my PC? Can I record music onto my PC? What's a sequencer? How can I get my PC to print a music score? What sort of a soundcard do I need? What hardware and software do I need? How do I connect a keyboard to my PC?:

Just a few of the questions you've probably asked. Well, you'll find the answers to all these questions, and many more, in this book. It will show you what can be done, what it all means, and what you will need to start creating your own music on your PC. It's an easy read, it's fully illustrated and it will help you understand how a computer can be used as a creative music tool.

It covers soundcards, sequencers, hard disk digital audio recording and editing, plug-ins, printing scores with notation software, using your PC as a synthesiser, getting music onto and off the Internet, using Windows, sample PC music setups, FAQs, a glossary, advice on hardware and software, and a list of industry contacts.

116 pages **Order code PC117** **£11.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£4.49**

CIRCUITS AND DESIGN

AN INTRODUCTION TO PIC MICROCONTROLLERS
Robert Penfold
Designing your own PIC based projects may seem a daunting task, but it is really not too difficult providing you have some previous experience of electronics.

The PIC processors have plenty of useful features, but they are still reasonably simple and straightforward to use. This book should contain everything you need to know.

Topics covered include: the PIC register set; numbering systems; bitwise operations and rotation; the PIC instruction set; using interrupts; using the analogue to digital converter; clock circuits; using the real time clock counter (RTCC); using subroutines; driving seven segment displays.

166 pages **Temporarily out of print**

PRACTICAL OSCILLATOR CIRCUITS
A. Flind
Extensive coverage is given to circuits using capacitors and resistors to control frequency. Designs using CMOS, timer i.c.s and op.amps are all described in detail, with a special chapter on ``waveform generator" i.c.s. Reliable "white" and "pink" noise generator circuits are also included.

Various circuits using inductors and capacitors are covered, with emphasis on stable low frequency generation. Some of these are amazingly simple, but are still very useful signal sources.

Crystal oscillators have their own chapter. Many of the circuits shown are readily available special i.c.s for simplicity and reliability, and offer several output frequencies. Finally, complete constructional details are given for an audio sinewave generator.

133 pages **Order code BP393** **£5.49**

PRACTICAL ELECTRONICS HANDBOOK – Fifth Edition. Ian Sinclair
Contains all of the everyday information that anyone working in electronics will need.

It provides a practical and comprehensive collection of circuits, rules of thumb and design data for professional engineers, students and enthusaists, and therefore enough background to allow the understanding and development of a range of basic circuits.

Contents: Passive components, Active discrete components, Circuits, Linear I.C.s, Energy conversion components, Digital I.C.s, Microprocessors and microprocessor systems, Transferring digital data, Digital-analogue conversions, Computer aids in electronics, Hardware components and practical work, Micro-controllers and PLCs, Digital broadcasting, Electronic security.

440 pages **Order code NE21** **£16.99**

COIL DESIGN AND CONSTRUCTIONAL MANUAL
B. B. Babani
A complete book for the home constructor on "how to make" RF, IF, audio and power coils, chokes and transformers. Practically every possible type is discussed and calculations necessary are given and explained in detail. Although this book is now twenty years old, with the exception of toroids and pulse transformers little has changed in coil design since it was written.

96 pages **Order code 160** **£4.49**

OPTOELECTRONICS CIRCUITS MANUAL
R. M. Marston
A useful single-volume guide to the optoelectronics device user, specifically aimed at the practical design engineer, technician, and the experimenter, as well as the electronics student and amateur. It deals with the subject in an easy-to-read, down-to-earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the i.c.s and other devices used are inexpensive and readily available types, with universally recognised type numbers.

182 pages **Order code NE14** **£20.99**

OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold
The first part of this book covers standard operational amplifier based "building blocks" (integrator, precision rectifier, function generator, amplifiers, etc), and considers the ways in which modern devices can be used to give superior performance in each one. The second part describes a number of practical circuits that exploit modern operational amplifiers, such as high slew-rate, ultra low noise, and low input offset devices. The projects include: Low noise tape preamplifier, low noise RIAA preamplifier, audio power amplifiers, d.c. power controllers, opto-isolator audio link, audio millivolt meter, temperature monitor, low distortion audio signal generator, simple video fader, and many more.

120 pages **Order code BP335** **£5.45**

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold
Getting started with logic circuits can be difficult, since many of the fundamental concepts of digital design tend to seem rather abstract, and remote from obviously useful applications. This book covers the basic theory of digital electronics and the use of CMOS integrated circuits, but does not lose sight of the fact that digital electronics has numerous "real world" applications.

The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

119 pages **Order code BP333** **£5.45**

AUDIO AND MUSIC

INTRODUCTION TO DIGITAL AUDIO (Second Edition) Ian Sinclair
The compact disc (CD) was the first device to bring digital audio methods into the home.

This development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers.

This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory is avoided, other than to state the end product.

128 pages **Order code PC102** **£8.95**

VALVE & TRANSISTOR AUDIO AMPLIFIERS
John Linsley Hood
This is John Linsley Hood's greatest work yet, describing the milestones that have marked the development of audio amplifiers since the earliest days to the latest systems. Including classic amps with valves at their heart and exciting new designs using the latest components, this book is the complete world guide to audio amp design.

Contents: Active components; Valves or vacuum tubes; Solid-state devices; Passive components; Inductors and transformers; Capacitors, Resistors, Switches and electrical contacts; Voltage amplifier stages using valves; Valve audio amplifier layouts; Negative feedback; Valve operated power amplifiers; Solid state voltage amplifiers; Early solid-state audio amplifiers; Contemporary power amplifier designs; Preamplifiers; Power supplies (PSUs); Index.

250 pages **Order code NE24** **£21.99**

AUDIO AMPLIFIER PROJECTS
R. A. Penfold
A wide range of useful audio amplifier projects, each project features a circuit diagram, an explanation of the circuit operation and a stripboard layout diagram. All constructional details are provided along with a shopping list of components, and none of the designs requires the use of any test equipment in order to set up properly. All the projects are designed for straightforward assembly on simple circuit boards.

Circuits include: High impedance mic preamp, Low impedance mic preamp, Crystal mic preamp, Guitar and GP preamplifier, Scratch and rumble filter, RIAA preamplifier, Tape preamplifier, Audio limiter, Bass and treble tone controls, Loudness filter, Loudness control, Simple graphic equaliser, Basic audio mixer, Small (300mW) audio power amp, 6 watt audio power amp, 20/32 watt power amp and power supply, Dynamic noise limiter.

A must for audio enthusiasts with more sense than money!

116 pages **Order code PC113** **£10.95**

VALVE AMPLIFIERS
Second Edition. Morgan Jones
This book allows those with a limited knowledge of the field to understand both the theory and practice of valve audio amplifier design, such that they can analyse and modify circuits, and build or restore an amplifier. Design principles and construction techniques are provided so readers can devise and build from scratch, designs that actually work.

The second edition of this popular book builds on its main strength – exploring and illustrating theory with practical applications. Numerous new sections include: output transformer problems; heater regulators; phase splitter analysis; and component technology. In addition to the numerous amplifier and preamplifier circuits, three major new designs are included: a low-noise single-ended LP stage, and a pair of high voltage amplifiers for driving electrostatic transducers directly – one for headphones, one for loudspeakers.

288 pages **Order code NE33** **£29.95**

LOUDSPEAKERS FOR MUSICIANS
Vivan Capel
This book contains all that a working musician needs to know about loudspeakers; the different types, how they work, the most suitable for different instruments, for cabaret work, and for vocals. It gives tips on constructing cabinets, wiring up, when and where to use wadding, and when not to, what fittings are available, finishing, how to ensure they travel well, how to connect multi-speaker arrays and much more.

Ten practical enclosure designs with plans and comments are given in the last chapter, but by the time you've read that far you should be able to design your own!

164 pages **Order code BP297** **£5.49**

BOOK ORDERING DETAILS

All prices include UK postage. For postage to Europe (air) and the rest of the world (surface) please add £2 per book. For the rest of the world airmail add £3 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to **Direct Book Service** or card details, Visa, Mastercard, Amex, Diners Club or Switch to: **DIRECT BOOK SERVICE, WIMBORNE PUBLISHING LIMITED, 408 WIMBORNE ROAD EAST, FERNDOWN, DORSET BH22 9ND**.

Books are normally sent within seven days of receipt of order, but please allow 28 days for delivery – more for overseas orders. *Please check price and availability (see latest issue of* Everyday Practical Electronics*) before ordering from old lists.*

For a further selection of books see the next two issues of *EPE*.

Tel 01202 873872 Fax 01202 874562. E-mail: dbs@epemag.wimborne.co.uk

Order from our online shop at: www.epemag.wimborne.co.uk/shopdoor.htm

BOOK ORDER FORM

Full name: ....

Address: ....

....

....

.... Post code: .... Telephone No: ....

Signature: ....

☐ I enclose cheque/PO payable to DIRECT BOOK SERVICE for £ ....

☐ Please charge my card £ .... Card expiry date.................................

Card Number .... Switch Issue No....................

Card Security Code .... (the last three digits on or just below the signature strip)

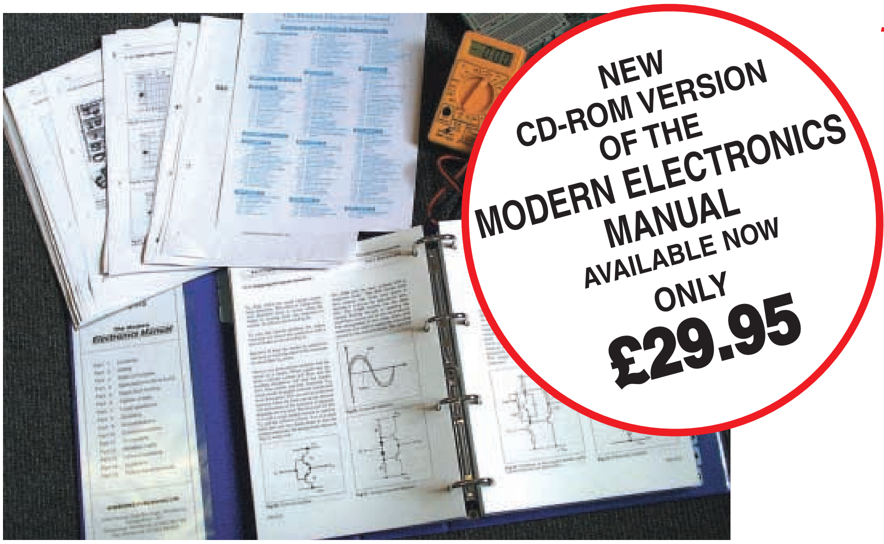
Please send book order codes: ....

....

Please continue on separate sheet of paper if necessary

WHETHER ELECTRONICS IS YOUR HOBBY OR YOUR LIVELIHOOD . . .
YOU NEED THE MODERN ELECTRONICS MANUAL and the ELECTRONICS SERVICE MANUAL

THE MODERN ELECTRONICS MANUAL (CD-ROM VERSION ONLY)



The essential reference work for everyone studying electronics

- *Over 800 pages*
- *In-depth theory*
- *Projects to build*
- *Detailed assembly instructions*
- *Full components checklists*
- *Extensive data tables*
- *Manufacturers' web links*
- *Easy-to-use Adobe Acrobat format*
- *Clear and simple layout*
- *Comprehensive subject range*
- *Professionally written*
- *Regular Supplements*

EVERYTHING YOU NEED TO GET STARTED AND GO FURTHER IN ELECTRONICS!

The revised CD-ROM edition of the Modern Electronics Base Manual (MEM) contains practical, easy-to-follow information on the following subjects:

BASIC PRINCIPLES: Electronic Components and their Characteristics (16 sections from Resistors and Potentiometers to Crystals, Crystal Modules and Resonators); Circuits Using Passive Components (10 sections); Power Supplies; The Amateur Electronics Workshop; The Uses of Semiconductors; Digital Electronics (6 sections); Operational Amplifiers; Introduction to Physics, including practical experiments; Semiconductors (5 sections) and Digital Instruments (3 sections).

CIRCUITS TO BUILD: There's nothing to beat the satisfaction of creating your own projects. From basic principles, like soldering and making printed circuit boards, to the tools needed for circuit-building, the Modern Electronics Manual and its Supplements describe clearly, with appropriate diagrams, how to assemble a radio, loudspeaker circuits, amplifiers, car projects, a computer interface, measuring instruments, workshop equipment, security systems, medical and musical circuits, etc. The Base Manual describes 12 projects including a Theremin and a Simple TENS Unit.

ESSENTIAL DATA: Extensive tables on diodes, transistors, thyristors and triacs, digital and linear i.c.s.

EXTENSIVE GLOSSARY: Should you come across a technical word, phrase or abbreviation you're not familiar with, simply look up the glossary included in the Manual and you'll find a comprehensive definition in plain English.

The Manual also covers **Safety** and provides web links to component and equipment **Manufacturers and Suppliers.** The most comprehensive reference work ever produced at a price you can afford, the CD-ROM edition of **THE MODERN ELECTRONICS MANUAL** provides you with all the ***essential*** information you need.

THE MODERN ELECTRONICS MANUAL (MEM – CD-ROM version only)

Revised CD-ROM Edition of Basic Work: Contains over 800 pages of information in Adobe Acrobat format. Edited by John Becker.
Regular Supplements: Additional CD-ROMs each containing approximately 500 pages of additional information on specific areas of electronics are available for £19.95 each. Information on the availability and content of each Supplement CD-ROM will be sent to you.
Presentation: CD-ROM suitable for any modern PC. Requires Adobe Acrobat Reader which is included on the MEM CD-ROM.

Price of the Basic Work: £29.95 POST FREE.

ORDER BOTH MANUALS TOGETHER AND SAVE £20

A mass of well-organised and clearly explained information is brought to you by expert editorial teams whose combined experience ensures the widest coverage
Regular Supplements to these unique publications, keep you abreast of the latest technology and techniques if required